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July 1986

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Field operations were conducted at CLIS from 15 July to 7 August 1986 to provide information related to the effects of recent dredged material disposal operations and assess the effectiveness of management controls. The only significant addition to the bathymetric features at CLIS was the development of the new CLIS-86 disposal mound, which had a maximum thickness of 2 meters and a radius of about 250 meters as detected with acoustic methods. The REMOTS® results showed that recently-deposited dredged material covered an area with a north-south radius of about 350 to 400 meters and an east-west radius in excess of 600 meters. An estimated 131,920 m^3 of disposed material was detected on the bottom using precision bathymetry and REMOTS® photography, compared to a scow log volume estimate of 164,045 m^3. No evidence of significant changes in topography at other mounds was detected.

None of the sediment chemistry results exceeded NERBC 'Moderate' upper limits except for Hg in the Norwalk Center sample, which was at 'High' levels. Notably, the mounds that have been capped (CS-1, CS-2, STNH-S and STNH-N) almost all showed relatively low (i.e., 'Low') contaminant concentrations. The levels of most of the parameters measured were either not different or significantly lower than reference levels. This suggests that the caps have been effective in isolating or at least "diluting" contaminants which might have been elevated in the capped dredged material.Sediment contamination levels for several parameters were significantly elevated compared to reference levels at the FVP, MQR, CLIS-86, NH-74 and Norwalk disposal mounds. This reflects the fact that contaminants were elevated in the dredged material deposited at these mounds.

The results of the benthic community analysis generally confirmed the REMOTS® infaunal successional designations and OSI rankings of the various mounds. The new CLIS reference station, STNH-N mound, and FVP mound were essentially similar in terms of mean OSI rank and species richness, while the MQR mound had a significantly lower mean OSI and species richness.

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MONITORING CRUISE
AT THE CENTRAL LONG ISLAND DISPOSAL SITE
JULY 1986

1.0 INTRODUCTION

The Central Long Island Sound (CLIS) Disposal Site has been under study by the New England Division (NED), Corps of Engineers since 1974. Several investigations have been conducted at CLIS to assess the impact of dredged material disposal on the surrounding environment and to study the effectiveness of capping contaminated dredged material to eliminate or limit the release of chemical components of environmental concern. These studies have been performed at a number of different disposal points within the CLIS Disposal Site boundary (Figure 1-1).

Field operations were conducted at CLIS during the period 15 July to 7 August 1986 to provide information related to the fates and effects of past and recent dredged material disposal operations and determine if management controls initiated by the New England Division had resulted in minimal dredged material dispersion and environmental impacts. Specifically, the first objectives of the field operations were to delineate the extent and topography of the dredged material deposit resulting from disposal during the 1985-86 season and assess the stability of past disposal mounds at the site to determine if changes in topography or dredged material distribution had occurred. To meet these objectives, precision bathymetric and REMOTS® sediment-profile photographic surveys were performed at the following disposal mounds: MQR, STNH-S, STNH-N, NOR, NH-74, NH-83, CS-1, CS-2, FVP and CLIS-86. Particular attention was paid to CLIS-86, the new mound created at the buoy in the northwest corner of the disposal site during the 1985-86 disposal season (Figure 1-1).

Another purpose of the REMOTS® surveys at the various mounds was to assess benthic recolonization and overall habitat quality through comparisons with past surveys. In addition, REMOTS® photography was used to help establish a new reference site outside the CLIS disposal site. Results from both past REMOTS® surveys and the Environmental Protection Agency's research program indicated that the formerly-used CLIS reference station was adversely affected by intensive sampling during the three year Field Verification Program (FVP). A REMOTS® survey was performed at a site approximately 2000 meters east and 500 meters south of the disposal site to assess its potential as the new CLIS reference station.

Another objective of the 1986 field operations was to examine two areas outside the disposal site boundaries for the presence of dredged material. Prior to the field operations, examination of disposal logs revealed the possibility that approximately sixteen barge loads of dredged material (approximately 50,000 m^3) may have been deposited in each of the two areas. These two areas, referred to as Ghost Site 1 and Ghost Site 2, were surveyed using precision bathymetry, side scan sonar, and REMOTS® photography to determine whether dredged material was present and therefore verify if errant disposal had occurred. Ghost Site 1 was located on the eastern margin of the CLIS disposal site; Ghost Site 2 was located on the northern edge of the site (Figure 1-1).

Sampling was also performed during the 1986 survey to determine the concentrations of selected chemical constituents in sediments from each of the ten disposal mounds and the new reference station. Grab samples were obtained at the center of each mound, and additional samples were taken at the STNH-N mound at previously determined transect stations for comparision with earlier chemical data. All samples were divided into Top (0-2cm) and Bottom (2-10cm) samples in order to assess any contaminant concentration variations that might occur with depth.

Another objective of the survey was to collect grab samples at each disposal mound and the new reference station for analysis of benthic community structure. Only the samples from the FVP, MQR, STNH-N mounds and the reference station were analyzed; the rest were preserved and archived. These mounds were chosen because STNH-N was found to have a different grain-size than the surrounding bottom, MQR was the only mound not affected by Hurricane Gloria, and FVP had long-term benthic data for comparision.

A final objective was to assess whether bioaccumulation of chemical contaminants had occurred at the FVP, MQR, STNH-N and CLIS-86 mounds based on comparison of contaminant body burden concentrations in organisms collected at the mounds versus those collected at the new CLIS reference station. Body burden levels at the FVP mound were compared with past data. Organisms were collected at MQR because this mound had shown anomalous benthic recolonization rates and different benthic community type compared with all the other CLIS mounds. The STNH-N mound was sampled to provide baseline data to assess the effectiveness of a sand cap for long term isolation of chemical contaminants from colonizing benthos.

2.0 METHODS

2.1 Navigation

The precise navigation required for all field operations was provided by the SAIC Integrated Navigation and Data Acquisition

System (INDAS). This system uses a Hewlett-Packard 9920 Series computer to collect position, depth, and time data as well as to provide real-time navigation. During a bathymetric survey, a display is provided to the helmsman of the research vessel with the survey lanes and the real-time position of the vessel indicated. The positional information is recorded on magnetic disk every second along with depth and time. The computer system calculates accurate positions from the range data provided by the positioning system and is capable of converting from state plane coordinates in the Transverse Mercator system to Lambert or Mercator coordinates.

Positions were determined to an accuracy of ±3 meters from ranges provided by a Del Norte Trisponder System. Shore stations were established in Connecticut over known benchmarks at Stratford Point and Lighthouse Point. These shore stations were same ones used in previous years to allow accurate comparisons of seasonal surveys.

2.2 Bathymetric and Side Scan Sonar Surveys

Depths were determined to a resolution of 0.3 meters (0.1 ft) using a Raytheon DE-719 Precision Survey Fathometer with a 208 kHz transducer. The fathometer was calibrated with a bar check at fixed depths below the transducer before the survey began. A Raytheon SSD-100 Digitizer was used to transmit the depth values to the SAIC computer system. Analysis of the bathymetric data corrects the raw depth values to Mean Low Water by adjusting for ship draft and for tidal changes for the duration of the survey. Noise generated in the data from fluctuating environmental conditions can result in errors such as spurious shallow depths. All data points in terms of depth and position were checked for such unreasonable values so that the final contour plots would not contain errors.

For the 1986 field operations, survey lanes were run east and west at 50 meter lane spacing over the entire CLIS disposal area. Surveys also were conducted over the ten individual disposal mounds (MQR, STNH-N, STNH-S, Norwalk, NH-74, NH-83, CS-1, CS-2, FVP and the new CLIS-86 mound) at 25 meter lane spacing. The closer lane spacing at these mounds provided good resolution for subsequent data analysis and the production of detailed depth contour charts.

The bathymetric surveys conducted at Ghost Sites 1 and 2 were run at 25 meter lane spacing over 600 by 600 meter areas centered at 41°8.96'N, 72°51.36'W (Ghost 1) and 41°9.64'N, 72°52.64'W (GHOST-2, Figure 1-1). A Klein Side Scan Sonar System also was used to survey these two sites. The side scan survey lanes were run at 150 meter spacing over a 900 by 900 meter area centered around the same points as the bathymetric surveys. The side scan system was set to a 100 meter sweep on both sides of the towed sensor array to provide complete coverage of the bottom in the two areas of interest.

2.3 REMOTS® Sediment-Profile Photographic Surveys

To better delineate the distribution of dredged material and assess benthic recolonization at each mound, the results of the July 1986 REMOTS® surveys were compared to previous surveys at the various mounds. All of the ten mounds within the CLIS disposal site have been surveyed in the past with REMOTS® photography, although the length of these histories as well as the survey format used and number of stations sampled varied (summarized in Table 2-1). The 1986 results at the disposal mounds were also compared with those at the new CLIS reference station, where twenty replicate REMOTS® photographs were obtained in a random pattern. A brief history and a summary of the methods employed at the individual disposal mounds follow.

At the FVP mound, numerous REMOTS® surveys were conducted prior to and following disposal in 1983. The results from the most recent surveys in June and October 1985 (Table 2-1) were compared to the present results. The July 1986 survey was conducted 31 months after disposal of contaminated Black Rock Harbor sediment at FVP and 10 months after the passage of Hurricane Gloria over Long Island Sound (September 27, 1985). As documented in DAMOS Contribution #57, Hurricane Gloria was an extremely high energy event which caused physical disturbance of the top few centimeters of the seafloor at the FVP mound (SAIC, 1989a). However, even prior to the hurricane there were indications that the region was experiencing stress factors during much of 1985. Chief among these stress indicators was a relatively shallow apparent RPD depth at stations throughout the FVP mound and exisiting CLIS reference station and the dominance of low-order successional infauna.

In the July 1986 survey at the FVP mound, twelve central stations were considered to be located on the main dredged material mound or mound flanks based on REMOTS® and bathymetric surveys conducted immediately after the FVP disposal operation (Figure 3-18). The remaining nine stations located off the dredged material mound were classified as edge and ambient. An attempt was made to obtain three replicate REMOTS® photographs at each station.

The 1986 surveys of STNH-N and STNH-S intersect at the approximate topographic centers of each disposal mound (station Center). Stations were located at 200 meters in each quadrant of these sampling grids. Both the STNH-N and STNH-S mounds originally were created from dredged material from Stamford Harbor, CT. In June 1979, the STNH-N mound was capped with sand and the STNH-S mound was capped with silt from New Haven Harbor, CT. Cap Sites 1 and 2 (CS-1 and CS-2), located on the western edge of the CLIS site, also were formed as capping experiments. A baseline REMOTS® survey was made of these areas in April 1983. Immediately following this baseline survey, Black Rock Harbor sediment at CS-1 was capped with silt from the upper portion of New Haven Harbor, and the same sediment at CS-2 was capped with sand from outer New Haven Harbor. A post-disposal reconnaissance REMOTS® survey was conducted in June 1983 to map the distribution of the dredged material and the thickness of the capping materials, and then several additional REMOTS® surveys were subsequently conducted (Table 2-1). In the present survey, three replicate photographs were obtained at each station, but only one replicate per station was analyzed for this report.

The most recent survey of July 1986 at the MQR mound occurred 38 months after disposal of Black Rock Harbor dredged materials followed by capping with New Haven Harbor muds. Stations in the grid were occupied at 200, 400, and 600 meters from station Center. Four stations were also located in the quadrants at the 200 meter positions. Attempts were made to obtain three replicate sediment-profile photographs at each station, and all pictures were analyzed for this report.

The 1986 sampling grid was different than that in the August 1985 MQR REMOTS® survey. In 1985, a 6 x 6 orthogonal sampling matrix was occupied with stations located 100, 300, and 500 meters north, south, east and west of station Center. One REMOTS® photograph was obtained from each station. The 29 October 1985 post-hurricane survey involved sampling 10 stations (3 replicates each) located on a cross-shaped grid at station Center, 50 and 200 meters on the N-S transect and 50, 200, and 1000 meter positions on the E-W transect. No quadrant stations were sampled.

The 1986 survey at the Norwalk (NOR) disposal mound involved the same sample grid used in August 1985. Three replicate sediment profile photographs were taken at each station, but only one photograph per station was analyzed for this report. This was the case for all the other CLIS mounds, except for FVP and MQR, where three replicates were analyzed.

The New Haven 74 (NH-74) disposal mound has the longest monitoring history of all the disposal mounds at CLIS, having been studied on an irregular basis since the original baseline study conducted in 1972. The NH-74 project involved the disposal of New Haven Harbor channel muds which were capped with clean sand, with the first REMOTS® survey conducted in September 1984. The 1986 survey was conducted at the same stations sampled in 1985 (Table 2-1).

REMOTS® monitoring at the New Haven 83 (NH-83) disposal mound began with a baseline survey in October 1984. The 1986 survey was conducted at the same stations sampled in August 1985.

The 1986 REMOTS® survey of the CLIS-86 disposal point was the first to be conducted at this site. This point was established east of the Cap Sites One and Two in October 1985; disposal has taken place since that time. The present survey was done on a cross-shaped grid at 17 stations, located at 200 meter intervals from station Center out to 600 meters. Quadrant stations were also located at 200 meter positions.

The REMOTS® surveys at the Ghost Site 1 and Ghost Site 2 areas each consisted of a 7 x 7 orthogonal grid with stations located 100 meters apart. Only One photograph was taken at each station.

REMOTS® photographs were taken with a Benthos Model 3731 Sediment-Profile Camera (Benthos, Inc. North Falmouth, MA). The REMOTS® camera is designed to obtain <u>in-situ</u> profile photographs of the top 15-20 cm of sediment. A detailed description of the REMOTS® camera operation and photograph analysis is presented in Damos Contribution #60 (SAIC, 1989b).

2.4 Sediment Chemical Analysis

Sediment samples were collected from the centers of the ten disposal mounds in the CLIS disposal area and at the reference station. In addition, eight stations around the STNH-N mound were sampled. For all of these stations, triplicate samples were collected using a 0.1 m^2 Smith-McIntyre grab sampler. Four polycarbonate plastic core liners (6.5 cm ID) were pushed into each sediment grab sample and extracted. These core samples were then separated into the Top (0-2 cm) section and the Bottom or remainder (about 2-10 cm depth) section and bagged separately for subsequent chemical analysis by the NED laboratory. The cores were separated to determine whether the surface sediment was relatively more or less contaminated than the deeper sediment. The samples were kept cold and returned to the NED laboratory where they were stored at 4°C until analyzed. The parameters measured included a suite of trace metals, and several organic constituents.

Sediment analyses were conducted using methods described by the U.S. Environmental Protection Agency (Plumb, 1981). Mercury (Hg) analysis was performed using acid digestion and cold vapor atomic absorption spectrophotometry; arsenic (As) analysis was accomplished using acid digestion and gaseous anhydride atomic absorption spectrophotometry. The other inorganic compounds (lead (Pb), zinc (Zn), chromium (Cr), copper (Cu), cadmium (Cd), nickel (Ni), and iron (Fe)) were analyzed using acid digestion and flame atomic absorption spectrophotometry.

Carbon, hydrogen, and nitrogen analyses were conducted with an autoanalyzer using a combustion technique. Oil and grease measurements were made by extracting the sediment with freon and then analyzing the freon by infrared spectrophotometry. PCBs were extracted with hexane and also analyzed by electron capture gas chromatography.

2.5 Benthic Community Analysis

Sediment samples for quantitative benthic analyses were obtained at the center of each of the ten disposal mounds as well as at the new CLIS reference station using a 0.1 m^2 Smith-MacIntyre grab sampler. At each station, five replicate grab samples were collected and sieved onboard the research vessel through nested 2 mm and 0.5 mm mesh screens. A visual description of each sediment grab was recorded prior to sieving. The material retained on the sieves was preserved with buffered formalin either for later sorting and identification in the laboratory or for archiving. Three of the replicate samples from the FVP, MQR, STNH-N Center stations and the reference station were analyzed, while the remaining two replicates from these areas were archived along with all the samples from the other disposal mounds.

In the laboratory, samples were stained with 0.2% rose bengal and sieved on 1.0 and 0.1 mm screens immersed in water. Light material was separated from each sieve fraction by repeated suspension and decantation. This fraction included most organisms other than molluscs and a few polychaetes in tubes. Sand, gravel, and shells made up the heavy fraction. Heavy fractions were sorted in glass trays with a white background. All other fractions were examined with binocular microscopes. All samples were analyzed under the supervision of Mr. Sheldon Pratt at the University of Rhode Island's Graduate School of Oceanography.

Organisms were identified to species in most cases. Individuals from all fractions were combined during counting. All individuals were stored in 70% alcohol. Sieve residues were described in laboratory notes and discarded. A combined reference collection of all species found in the 1986 Central and Western Long Island Sound Disposal Site samples was archived at the University of Rhode Island Graduate School of Oceanography under the direction of Mr. Sheldon Pratt.

The STNH-N samples contained a large number of Polydora polychaetes and their tubes. The coarse fraction of STNH-N-2 took over 20 hours to sort and yielded 2,200 Polydora. To assure the timely completion of all samples, the remaining coarse and fine material from STNH-N were split into 1/2 and 1/4 fractions.

2.6 Body Burden Analysis

Test organisms for body burden analysis were collected from four of the disposal mounds (STNH-N, FVP, MQR, and CLIS-86) and at the new reference station using a Smith-McIntyre grab. Sediment was sieved through a 2 mm mesh and the deposit-feeding organisms (the polychaete, Nephtys incisa) were isolated and placed in seawater at ambient temperature. Sufficient biomass was collected for triplicate analyses at all of the stations except CLIS-86, where only enough biomass could be collected for a single sample. The animals were allowed to purge any sediment from their guts for 24 hours before they were frozen for transport to the laboratory for chemical analysis. The polychaetes were analyzed for eight trace metals and PCBs at the SAIC laboratory in La Jolla, California. A detailed description of the methods used for the analysis of the polychaete tissue can be found in DAMOS Contribution #60 (SAIC, 1989b).

The quality of the tissue trace metal data was assured in several ways. These included the analysis of blank samples and measurements of the precision and accuracy of the results. Blank concentrations were all well below the element concentrations for these samples. Measurements of the precision of the inorganic analyses were made by doing replicate analysis of a sample of Pitar morrhuana (collected at the New London Disposal Site) and NRC Lobster Hepatopancreas Tissue (Table 2-2). The relative standard deviations of replicate analyses of the Pitar morrhuana were less than 20% for all elements.

Results from the analyses of certified NRC Lobster Hepatopancreas Tissue showed excellent accuracy for the inorganic analysis methods. The concentrations reported for all eight elements in the NRC tissue were very similar (91-108% agreement) to the NRC values, indicating good accuracy (Table 2-2).

Samples for organic analysis were first sonicated with methanol and then three additional times with hexane. The methanol/hexane mixture was partitioned in a separatory funnel and the aqueous methanol was extracted with additional hexane. The combined hexane extracts were decanted through Na_2SO_4 and concentrated to 1.0 ml using standard Kuderna-Danish (K-D) equipment and techniques. Next, 0.5 ml aliquots of the concentrated samples were adjusted to 1.0 ml with acetone and eluted with hexane over neutral alumina columns.

Samples were analyzed for their PCB content according to EPA Federal Register Method 608, using a Hewlett Packard 5840A gas chromatograph equipped with an electron capture detector and a 30 m DB-5 fused silica capillary column. The column oven temperature was programmed from an initial temperature of 45°C to 290°C using a three-step program. The program rate was 7°C/min to 164°C, then 2°/min to 214°C, and finally 10°C/min to 290°C. Quantification was by the external standard calibration method.

Tissue samples were screened for the presence of several different PCB formulations. These included Aroclors 1016, 1221, 1232, 1242, 1248, 1254 and 1260. Aroclor 1254 is the most prevalent mixture in the marine environment of the Northeast region.

Because each formulation contains different amounts of chlorine, the response factors can vary between mixtures. The detection limits for Aroclors 1016, 1242 and 1260 were the same as that achieved for 1254. The detection limits were higher for the other mixtures by factors of 4.0, 2.0 and 1.6 for Aroclors 1221, 1232 and 1248, respectively. In order to report a total PCB concentration one would have to add the concentrations of all the different mixtures.

The PCB analyses were quality assured by measuring the recovery of a surrogate compound (dibutylchlorendate) in each sample. The recovery of this compound was 69% ±16 for the Central Long Island Sound disposal site samples.

3.0 RESULTS

3.1 Bathymetric Surveys at the CLIS Disposal Mounds

The disposal mounds were evident as rapid changes in topography (Figure 3-1). Comparison with the results of the identical survey in 1985 (Figure 3-2) revealed the only significant addition to be the accumulation of new dredged material at the buoy (designated as the CLIS-86 mound). Modifications in the analysis software enabled the production of higher resolution contour plots for the 1986 surveys.

The minimum depth at the peak of the CLIS-86 mound was 16.6 meters; this mound apex was located approximately 60 meters east of the disposal buoy location (Figure 3-3). A detailed comparison of this area was made with the survey conducted in August 1985 to determine where depth differences occurred (Figure 3-4) and to estimate the volume of material deposited since that time. This volume difference calculation resulted in an estimate of approximately 79,200 m^3 of dredged material deposited during the 1985-86 disposal season. Tabulation of scow logs indicated that approximately 164,045 m^3 of dredged material was deposited at CLIS-86 during the period 11 October 1985 to 5 May 1986.

The standard error of the depth difference volume calculation for the 650 x 700 meter survey area at CLIS-86 was determined to be 4,246 m^3, resulting in 95% confidence limits of 74,954 to 83,446 m^3 of dredged material detected on the bottom by precision bathymetry. A detailed description of the calculations required to determine this error and the 95% confidence limits around it can be found in DAMOS Contribution #60 (SAIC, 1989b). This calculation simply implies that the actual (and unknown) volume difference will occur within the lower and upper confidence limits with a probability of 0.95.

Figures 3-5 through 3-13 present enlargements of each individual disposal mound using the same data that produced Figure 3-1 for the mounds: FVP, STNH-N, STNH-S, CS-1, CS-2, MQR, Norwalk, NHAV-83, and NHAV-74 (Figure 1-1), respectively. Because of the areas defined by the chart boundaries, sections of neighboring mounds can be seen in the figures. Direct comparison of the results of the 1985 and 1986 surveys did not reveal any significant changes in topography that could be attributed to erosion.

3.2 Bathymetry and Side Scan Surveys at Ghost Sites 1 and 2

Examination of the results of the bathymetric surveys at the GHOST-1 and GHOST-2 sites (Figures 3-14 and 3-15) revealed the lack of any significant accumulation of sediment at any particular location. Because these areas were outside the CLIS area normally surveyed, a comparison with earlier results was not possible. At GHOST-1, the only noticeable variations in depth were on the order of 20 cm. At GHOST-2, these variations were only as much as 10-15 cm.

Analysis of the side scan records for the GHOST-1 and GHOST-2 areas did not identify any large accumulation of dredged material. Figure 3-16 presents the survey lanes and the areas of high reflectance that were evident on the side scan records at GHOST-1. Only one site revealed any distinct reflection and could not account for the 50,000 cubic yards of dredged material suspected of being deposited there. The remainder of the bottom was fairly smooth and uniform. Several areas of high reflectance were scattered throughout the GHOST-2 survey area (Figure 3-17). Although no distinct areas could be identified as scow loads of dredged material, the difficulty in distinguishing the dredged material from the ambient bottom increases with time. The one identifiable feature at GHOST-2 is a sunken "pocket scow" (Figure 3-17).

3.3 REMOTS® Sediment-Profile Surveys at the CLIS Disposal Mounds

3.3.1 FVP Mound

The distribution and thickness (cm) of apparent dredged material at the FVP mound (Figure 3-18) was similar to those mapped in earlier surveys. Some stations that were previously shown to be located on the mound and flank perimeter showed no apparent dredged material layer to be present. This may have been caused by either complete mixing of the Black Rock material into the ambient bottom or the loss of high reflectance sediment (ferric hydroxide-coated particles) of the buried pre-disposal surface (datum of reference).

All stations showed an apparent grain size major mode of $\geq$ 4 phi (silt-clay) with subordinate sand modes ranging from very coarse to very fine sands (-1 to 3 phi). Since the January 1984 survey, fine sand (3-2 phi) has dominated the surface texture of station Center. This sand layer has been interpreted to represent a lag deposit resulting from washing of fines from the apex of the mound. In the October 1985 survey, fine sand layers were also found to be developing at stations 150E and 100W. It was suggested that this was caused by Hurricane Gloria. These stations have continued to show sandy surfaces and, in addition, all other FVP stations showed a sand component in the near surface sediment (Figure 3-19).

Some of the sand-sized particles were apparently biogenic (foraminiferal tests and molluscan shells) and may represent the gradual accumulation of skeletal material as successive populations contribute their hard parts to the sedimentary matrix. The sand fraction in other cases consisted of mineral grains. It is possible that the sand fraction of the near-surface sediment increased due to the onshore to offshore transport of sand related to Hurricane Gloria. This inference is based on the presence of a 9 cm thick, fine sand (3-2 phi) layer overlying silt clay at a station located in 50 feet of water approximately 4000 m north-west of the FVP area (SAIC, 1989a).

In June 1985, approximately 80% of the FVP photographs showed the widespread presence of reduced mud at the sediment surface including the mound, flanks, and ambient bottom. Reduced sediment at the surface was not seen at the CLIS reference station. The origin of this reduced sediment was attributed to surface erosion of the FVP mound and the local redistribution of Black Rock Harbor muds. In October 1985 (post-Hurricane Gloria), about 50% of the photographs showed reduced sediment at the surface. Two of the 20 CLIS reference photographs in October also showed reduced sediment at the sediment-water interface. In the 1985 case, the effects of Hurricane Gloria were suggested to be the agent eroding the top 2-3 cm of oxidized, biogenically-reworked upper sediment.In this survey, only one replicate at station 500W showed reduced mud clasts at the sediment surface; it is possible that this was an artifact introduced by the REMOTS® prism window wiper. Reduced sediment was not seen at the sediment-water interface in any of the photographs from the new CLIS reference station. In this survey, there was little or no evidence of exposure of the reduced Black Rock Harbor muds to the water column.

The frequency distributions of boundary roughness values for the dredged material mound, edge and ambient stations, and the new CLIS reference station were all similar, with the major mode for small-scale topographic relief at the 0.8 cm class interval (Figure 3-20). These boundary roughness values were not significantly different from those measured in October 1985. However, both the October 1985 and July 1986 boundary roughness values were significantly greater than those measured in the June 1985 survey ($p < 0.05$, Mann-Whitney U-test).

Seasonal changes in the rates of biogenic reworking as well as physically-induced surface erosional and depositional events can result in changes in boundary roughness. At the FVP area, the increase in boundary roughness values in October 1985 was physically-induced, attributable to the influence of Hurricane Gloria. In the present survey, the boundary roughness was attributed to increased biological activity in the area; a higher rate of biogenic reworking of surface sediments is normally expected during the warmer months of the year.

A layer of floccular material, interpreted to represent a depositional layer of detritus associated with a decaying spring plankton bloom was described in the March 1985 report. This layer was not observed in any REMOTS® photographs from the present survey.

Average RPD depths were 3.67 ± 0.90 cm at mound stations and 4.06 ± 1.22 at the edge and ambient stations (Figures 3-21 and 3-22). The new CLIS reference station had a mean RPD depth of 3.39 ± 0.77 cm. The RPD depths at the edge and ambient stations were significantly deeper than those at the mound stations and the new CLIS reference station ($p < 0.05$, Mann-Whitney U-test). There was no significant difference in RPD depths between the mound stations and the new CLIS reference station ($p = 0.0618$, Mann-Whitney U-test).

The trend toward shallower RPD depths, which began in March 1985 and was later exaggerated by the passage of Hurricane Gloria, apparently has been reversed at the FVP mound. The average RPD depths for the mound, edge and ambient and new CLIS reference stations were significantly deeper than those recorded at these stations in both the June and October 1985 REMOTS® surveys ($p < 0.001$, Mann-Whitney U-test). Following the hurricane, the October 1985 survey revealed that stations near the center of the mound totally lacked oxidized surface layers as a result of scouring; highly-reduced dredged material that was formerly underlying aerated sediment was visible at the sediment-water interface. Since that time, the average RPD depth has returned to a level comparable to what it was before June 1985, when "stress" or disturbance factors were first indicated (Figures 3-23a and b).

Relative to both the June and October 1985 surveys, the number of stations from the FVP disposal area that showed Stage III seres has increased dramatically (Figure 3-24). For example, in October 1985 only 28% of the photographs from the mound stations, 35% of edge and ambient station photographs and 30% of the photographs from the CLIS reference station exhibited Stage III assemblages. At that time, these values represented a low point in a trend of progressively decreasing presence of Stage III assemblages at these stations during 1985. In the present survey, 66% of the mound station replicates exhibited Stage III seres compared with 73% for the edge and ambient stations and 90% for the new CLIS reference station.

These results suggest that the "retrograde" successional status of the FVP mound has been reversed, which is consistent with the observed deepening of the RPD depths. The successional status of the new CLIS reference station is comparable to that found in surveys prior to 1985, when over 80% of the station replicates consistently showed Stage III seres to be present.

The mapped distribution of REMOTS® Organism-Sediment Index (OSI) values showed no significant difference in OSI values among mound, edge and ambient, and new CLIS reference stations (Figure 3-25). The frequency distributions of OSI values (Figure 3-26) at the mound and edge and ambient stations both were left skewed, with major modes at +11 and minor modes at +7. Likewise, the distribution of OSI values at the new CLIS reference station was left skewed with a major mode at +10. The Organism-Sediment Index values have increased significantly since the October 1985 survey ($p < 0.001$, Mann-Whitney U-test), when the area exhibited a broad range of OSI values indicative of extreme patchiness in benthic conditions. The increase in OSI values obviously reflects the deepening of the RPD and the increase in the number of Stage III seres since October 1985. There appears to have been a convergence in the OSI values at the FVP mound and the new CLIS reference station.

3.3.2 Stamford-New Haven North (STNH-N) Mound

The STNH-N disposal mound was capped with a layer of sand from New Haven Harbor in June 1979. Bathymetric surveys performed immediately following capping showed that the sand cap had a maximum thickness of 3.5 meters at the mound apex (SAIC, 1980). Cap thickness varied in different places on the mound, but most of the sand appeared to be concentrated within a 100 to 150 meter radius to the north, west and south of the mound apex. Sand cap layers on the order of 1 meter thick extended as far as 200 meters east of the mound apex. Beyond the 100 to 200 meter radius, cap thickness decreased considerably and was probably less than 20 centimeters in most surrounding areas.

In the August 1985 survey, 37 of 43 REMOTS® photographs showed a major modal grain-size of $\geq$ 4 phi (silt-clay), with the exception of station Center and 200 S which showed very fine sand and station 200 E, which showed a mud/sand/mud stratigraphy in the upper 20 cm of the sediment. Those stations away from the mound which did not show the original surface sand cap were interpreted to represent biogenically mixed sediments. Bioturbation apparently had mixed the relatively thin (i.e., less than 20 cm thick) surface sandy sediment with both underlying mud and newly settled mud from the water column derived from ambient resuspension. The post-hurricane survey in November 1985 showed evidence of surface scour and erosion at most stations (Figure 3-27), and post-storm boundary roughness was significantly increased relative to the pre-storm (August 1985) survey (SAIC, 1989a).

In the present survey, only station Center was found to have a major mode in the sand fraction (3-2 phi or fine sand). The upper 10 to 12 cm of the sand cap at this station appeared to remain relatively free of mixing with mud (Figure 3-28). This probably resulted from the cap being thicker than the particle bioturbation depth at this station, as well as from recently settled fines being washed from the surface by bottom currents which are accelerated as they flow up and over the mound apex. Although the silt-clay fraction dominated at other stations ($\geq$ 4 phi), the upper few centimeters of most stations contained a significant quantity of sand. In most cases, the depth of disposed material was greater than the prism penetration depth into the bottom (Figure 3-29). The only stations which did not show evidence of a surface sand fraction were 200N and 400N.

The boundary roughness frequency distribution for July 1986 had a major mode at 0.8 cm (Figure 3-30). The boundary roughness values were not significantly different than those measured in August 1985 ($p = 0.63$; Mann-Whitney U test) nor were they different from those at the new CLIS reference station ($p = 0.68$).

The frequency distribution of RPD values at this mound (Figure 3-30) and the mapped values (Figure 3-31) showed no significant difference from the new CLIS reference station ($p = 0.53$, Mann-Whitney U-test). They did not show any statistical difference from those measured in August 1985 as well ($p = 0.55$).

All stations except 200W showed the presence of head-down feeders (Stage III successional seres) (Figures 3-32 and 3-33). These deposit-feeders are very efficient in particle bioturbation, and their widespread distribution on the disposal mound (Figure 3-34) may account for mixing of the original sand cap with the underlying mud at stations away from the mound center. The STNH-N mound historically has had a high successional status relative to other CLIS disposal points. For example, seventy-nine percent of the station replicates were in a Stage III condition in August 1985.

The frequency distribution of OSI values (Figure 3-30), and their spatial distribution (Figure 3-35) showed relatively high indices for all stations with the exception of station 200W. In past REMOTS® monitoring in Long Island Sound, we have found that OSI values greater than +6 represent benthic habitats that have not experienced physical or chemical (e.g., low oxygen) disturbance in the recent past. The July 1986 OSI values for mound stations (stations on dredged material) were not significantly different from those measured at the new CLIS reference station (sample mean = 9.5; $p = 0.56$, Mann-Whitney U-test) nor were they significantly different from those measured in August 1985 ($p = 0.66$).

The STNH-N mound had the highest benthic habitat quality relative to other CLIS disposal mounds and was indistinguishable in its REMOTS® values from those measured at the new CLIS reference station. The effect of Hurricane Gloria on this disposal mound apparently was minor and transient, because the present survey showed results comparable to the pre-hurricane survey of August 1985.

3.3.3 Stamford-New Haven South (STNH-S) Mound

No change in the major modal sediment grain-size has been detected in this survey relative to earlier surveys. All stations had a major mode in the $\geq$ 4 phi (silt-clay) size class with many stations having a minor sand mode.

For those stations at the STNH-S mound where dredged material was identified, its thickness appeared to be deeper than the penetration of the camera's prism (distribution shown Figure 3-36). Stations 400S, 600S and 600E showed no evidence of dredged material, and the presence of dredged material at stations 400E and 200SW was questionable. This distribution of dredged material is comparable to that mapped in August 1985, which showed the presence of reduced sediment at or near the sediment surface in almost half the station replicates. No station showed evidence of this condition in the present survey. Stations 200W and 200NW showed similar disposal stratigraphy (Figure 3-27); the same superposition of materials with different grey scales or optical reflectance (low over high over low) was seen at both stations. The low reflectance surface layer, which was 3 to 4 cm thick, did not appear to be associated with many macrofauna, and the sharp contacts of these units suggest that bioturbational mixing rates were slow or nonexistent.

The post-Hurricane Gloria REMOTS® survey (November 1985) showed this area to be affected by the storm. The photographs revealed shell-lag deposits, mud clasts, exposed worm tubes, and reduced sediment patches near the surface. Surface erosion, based on the lengths of exposed worm tubes, was estimated to range from 0.3 to 0.4 cm. Station CTR appeared to be most affected; the mean apparent RPD depth decreased 3 cm in thickness after the storm. This was attributed to physical removal of the surface sediment by near-bottom turbulence. No remaining evidence of such storm-related phenomena was indicated in the present survey.

The frequency distribution of small scale boundary roughness had the major mode at 0.8 cm (Figure 3-38). With a sample mean of 1.1 cm, the distribution of values was significantly greater than both the new CLIS reference station (mean = 0.70; $p = 0.03$, Mann-Whitney U-test) and the values measured in August 1985 ($p = 0.008$). The increase in boundary roughness may be attributable to the increased disturbance or sediment redistribution experienced as a result of Hurricane Gloria.

The frequency distribution of mean apparent RPD depths at STNH-S was bimodal, with a major mode at 4.0 cm and a minor mode at 2.0 cm (Figure 3-38). Mean RPD values for stations 200W and 200NW have not been included in this frequency distribution because of their anomalous stratigraphy (Figure 3-37a and b). At these two stations, the surface consisted of 3 to 4 cm of intermediate-reflectance sediment overlying a high reflectance layer 5 to 8 cm thick. Because it is not possible to determine if the surface layer consisted of oxidized or reduced sediment relative to the underlying unit, RPD and OSI values could not be assigned to these two stations. However, these two stations may have very low OSI values if the surface sediment was sulphidic. The 5 to 8 cm thick high reflectance unit, in turn, covered a low reflectance unit of unknown thickness which extended below the limit of penetration of the optical prism. Station 200NW showed horizontal fractures in this low reflectance unit (Figure 3-37b). This deformation was caused by brittle fracture of the sediment as it was sheared by the descending optical prism. Such brittle fracture takes place in fine-grained sediments when the water content is less than 50%. Low water content is typical of overconsolidated sediment. Although the stratigraphy at stations 200W and 200NW had not been observed in previous surveys, a layer of cohesive dredged material may occupy this quadrant of the disposal area. The above interpretation is supported by diver observations made on August 13, 1985: "The substrate consisted of fine silt (1 to 2 cm deep) over a cohesive clay base.....Eroded clay clump material was present" (SAIC, 1989a).

The two distributional modes (Figure 3-38) described above appear to have been spatially separated according to station location (Figure 3-39). Values less than 3 cm deep were located at stations 400W and 600W. Shallow values were also located in the SE quadrant (200E, 200SE, 400S, and 600S). The RPD values measured in this survey were not significantly different from those measured in August 1985 ($p = 0.38$, Mann-Whitney U-test). However, in a direct one-to-one comparison, 4 stations appeared to have much shallower RPD values than measured in August 1985: 400W, 200E, 200SE, and 600S. The shallower RPD values at these stations may be related to the lingering effects of Hurricane Gloria, which caused surface erosion at this mound. Post-storm RPD values are available for station CTR, 200 meter stations, and 600E (Figure 3-39).

Most stations (10 out of 17 or 59%) were in a Stage I successional sere (Figure 3-40). Five of these stations have not progressed beyond this sere since August 1985 (CTR, 200W, 400W, 200NW, and 200SW). Five stations apparently experienced retrograde succession since August 1985 (200N, 400N, 600N, 600S, and 600E), while only one station (200NE) apparently changed in successional status (I to I-III) since August 1985. These apparent changes in successional status must be interpreted with caution. In August 1985, three replicates were taken at each station; these data showed that within-station patchiness was high with respect to successional status. The present survey was based on analysis of only one replicate per station, so the issue of within-station variance of benthic community structure cannot be addressed.

The absence of Stage III seres from some stations may be related to the presence of relic overconsolidated sediment at depth (Figure 3-37). This sediment may: 1) inhibit burrowing by Stage III taxa and 2) be low in nutrients for detritivores. The aggregate successional status of the STNH-S mound was much lower than that at the new CLIS reference station, where 18 replicates out of 20 (90%) showed Stage III seres to be present.

The frequency distribution of OSI values ranged from +4 to +11 with a major mode at +7 (Figure 3-38). Stations 200W and 200NW have again been deleted from this distribution due to their anomalous stratigraphy. These OSI values were not significantly different from the August 1985 data set ($p = 0.84$, Mann-Whitney U-test); however, they were significantly lower than those calculated for the new CLIS reference station ($p = 0.0209$). Areas of the STNH-S disposal mound where OSI values were less than 6 were stations 400W, 200SW, and 600S (Figure 3-41). This was generally the area of low OSI values mapped in August 1985. The low OSI values on the west side of the STNH-S mound may be related to the presence of relic, overconsolidated sediment which may impede burrowing by infauna. This sediment may also be devoid of labile organic matter, which would sustain deposit feeders. Alternatively, this sediment may contain toxic compounds which has kept this area in an anomalously low successional status. In order to determine the probable cause for this low OSI condition, further study would be necessary.

3.3.4 Cap Sites One (CS-1) and Two (CS-2)

The Black Rock Harbor sediment at Cap Site 1 was covered with silt from the upper portion of New Haven Harbor in May 1983. REMOTS® surveys performed immediately following capping found that the cap material was visually indistinguishable from the underlying sediment, precluding an accurate estimate of cap thickness (SAIC, 1984). The REMOTS® surveys did show that the entire deposit (Black Rock Harbor sediment plus cap material) had a thickness in excess of 10 cm in a 150 to 200 meter radius around the mound center. The thickness decreased from 10 cm to 0 cm within about a 400 meter radius of the mound center.

In the July 1986 survey, the CS-1 stations had a grain-size major mode of $\geq$ 4 phi (silt-clay) with the exception of station 600N, which had a major mode of 3-2 phi (fine sand) (Figure 3-42). Station 600N is located on the flank of CS-2; this sand apparently represented capping material deposited at CS-2. This extension of the sand cap at station 600N was also noted in the August 1985 survey. Minor modes of medium, fine, and very fine sand were present near the surface of several stations. The origin of this sand may be related to the winnowing of fines or to the broad dispersal of sand from nearshore erosion during Hurricane Gloria in September 1985. The post-hurricane REMOTS® survey conducted on October 28, 1985 showed the widespread appearance of sand at the sediment surface for the first time at CS-1.

The cap deposited at CS-2 in May 1983 predominantly consisted to very fine sand (4-3 phi). Post-capping bathymetric and REMOTS® surveys showed the cap had a maximum thickness of 1.4 meters at the mound apex, with most of the sand concentrated within a radius of 100 to 200 meters. Beyond this, cap thickness decreased from 4 cm to 0 cm within a 400 meter radius of the mound apex (SAIC, 1984). As early as September 1984, the sand cap was becoming less recognizable due to the addition of silt-clay. This was attributed primarily to bioturbation resulting in mixing of the sand cap with underlying fine-grained sediments, similar to what was observed at the STNH-N mound. Some sedimentation of silt-clay into the area from tidal resuspension of the ambient seafloor may also have contributed. In the August 1985 survey, a distinct sand cap could not be seen, and the major textural mode for most station replicates was $\geq$ 4 phi. At the same time, 5 stations located on the western side of the mound were found to have a layer of silt-clay overlying the original sand cap. This was attributed to enhanced sedimentation on the "lee-side" of the mound. The present survey revealed that all stations (except 600N) had a major textural mode of silt-clay ($\geq$ 4 phi). The silt-clay over sand stratigraphy described in 1985 apparently has been lost through bioturbation. The only station which resembles the original sand-over-mud stratigraphy is CS-1 station 600N (Figure 3-42). A minor sand component can be seen at other stations. This sand may represent the remnants of the original sand cap or may be related to the post-Hurricane Gloria distribution of sand from nearshore (as described for CS-1 above).

Disposed dredged materials were present at all stations except 400N at CS-1; at CS-2, no apparent dredged material was detected at stations 400E, 600E, 400W, 600W, 400N, 600N, 400S and 600S (Figure 3-43). The optical "signature" of disposed materials apparently has been "erased" from the flanks of CS-2. The fact that disposed material was detected at more stations at CS-1 than CS-2 is probably related to the more recent disposal activities that have taken place immediately adjacent to CS-1 (between 1984 and 1985).

The frequency distributions of small-scale boundary roughness for both CS-1 and CS-2 showed a major mode at the 0.8 cm class interval (Figure 3-44). The mean values for each mound were 0.86 ± 0.28 cm and 0.91 ± 0.30 cm, respectively. These values did not differ significantly from those obtained in August 1985.

The post-Hurricane Gloria REMOTS® survey of October 18, 1985 showed that the mean apparent RPD depths were significantly less than those measured in August 1985. Storm-associated erosion reduced the apparent RPD depths to less than 3 cm below the sediment-water interface. Since October 1985, the mean apparent RPD depths have increased at both mounds, but at unequal rates. Most apparent RPD depths at CS-1 fell within the 3.0 cm class interval (mean = 3.53 cm

± 0.81 cm.), while most values at CS-2 fell within the 4.0 cm class interval (mean = 4.10 ± 0.68 cm.; Figure 3-45). The RPD values at CS-2 were significantly greater than those at both CS-1 and the new CLIS reference station ($p < 0.05$, Mann-Whitney U-test). These deeper RPD's may be attributed in part to greater sediment porosities resulting from the increased grain-size associated with the sand cap at CS-2. For both mounds however, the RPD values did not differ significantly from those measured in August 1985 ($p = 0.35$ at CS-1; $p = 0.46$ at CS-2). The mean RPD values at Center and 200M stations at CS-1 were relatively deep (Figure 3-46), which suggests that bioturbation was actively occurring at stations located on the thickest part of the disposal mound. All stations at CS-2 except 600N had relatively deep mean apparent RPD depths.

Half of the CS-1 stations had Stage III taxa present, including station Center (Figures 3-47 and 3-48). In August 1985, stations 200N, 400W, 200NW, 200NE, and 200SE had only Stage I assemblages present; the remaining 12 stations had either a Stage II or III assemblage present. Because only one replicate per station was analyzed in this survey, small-scale (i.e., within-station) patchiness in the distribution of Stage III organisms was not assessed. The apparent change in successional status is difficult to interpret because Stage III organisms could have been missed. In the August 1985 survey (based on three replicates per station), CS-2 had only four stations dominated by a Stage I sere: 400W, 200E, 200SW, and 400S. Other stations consisted of a mixture of Stage I and Stage III seres. In the present survey, seven stations appeared to be in a Stage I condition: 200N, 200W, 400W, 600W, 200SW, 400S, and 600S (Figure 3-48). Station Center was populated by Stage III taxa and shows evidence of deep bioturbation (Figure 3-47).

The major difference between the Organism-Sediment Index frequency distributions for CS-1 and CS-2 is that CS-2 had more values in the +10 and +11 class intervals and fewer values in the +5 and +6 class intervals (Figure 3-49). The mean OSI value at CS-2 was very high (9.24 ± 1.92), but not significantly different from CS-1 ($p = 0.067$) or the new CLIS reference station ($p = 0.60$, Mann-Whitney U-test). In addition, the OSI values at both mounds did not differ significantly from those measured in August 1985.

The mapped distribution of OSI values at CS-1 showed a mixture of high and low values over the mound, with no clear spatial trends relative to the mound center (Figure 3-50). The spatial distribution of OSI values at CS-2 showed that the benthic habitat quality was uniformly high. Only station 200N and 400S had values of +6, the threshold value for detecting disturbed habitats with this parameter. These two stations apparently lag the rest of the locations sampled on the mounds in terms of bioturbation depth and successional status. The reason for this lag cannot be assessed from the photographs.

3.3.5 Mill-Quinnipiac River (MQR) Mound

In the present survey, the major modal grain-size continued to be $\geq$ 4 phi (silt-clay) for all stations. As in the August 1985 survey, the near-surface sediment at most stations consisted of a subordinate mode falling within the 3-2 to 2-1 phi size classes (fine to medium sand). Disposed material was present at all stations except 600S (Figure 3-51). The thickness of dredged material exceeded the penetration of the camera prism at all stations except station 600W. Methanogenic sediments were detected at station 200N (two out of three replicates) and in one replicate at station 200E (Figure 3-52). Methane was detected previously at station Center and 200N in the post-hurricane survey of October 1985.

The small-scale boundary roughness frequency distribution (Figure 3-53) showed a major mode at the 0.4 cm class interval (sample mean = 0.7 cm). Surface boundary roughness did not changed significantly from values measured in August 1985 nor were they significantly different than those measured at the new CLIS reference station.

The mean apparent RPD depth frequency distribution showed a major mode at the 3.0 cm class interval (Figure 3-53). Mean RPD depths at MQR were significantly shallower than those measured at both the new CLIS reference station ($p < 0.001$, Mann-Whitney U-test) and the MQR mound in August 1985 ($p < 0.001$). The mapped distribution of mean apparent RPD depths (Figure 3-54) showed no clear spatial pattern; the transect segment from Center to 600E consists of uniformly low values, and two replicates of station 600N had very thin RPD depths, possibly associated with local surface disturbance.

Thirty-one percent of the REMOTS® photographs from MQR showed the presence of well-developed subsurface feeding voids (Figures 3-55 and 3-56). This indicates that Stage III head-down feeders have successfully populated the MQR disposal mound for the first time since our initial survey in January 1983. However, it is not clear if this colonization was primarily the result of larval recruitment or immigration of adults. It is possible that turbulence associated with the passage of Hurricane Gloria in September 1985 may have caused the passive redistribution of benthic invertebrates. The August and October 1985 REMOTS® survey showed Stage III seres at only two stations in each survey. Future REMOTS® surveys at the MQR mound will be important for documenting the progressive colonization of the area by Stage III taxa.

The frequency distribution of Organism-Sediment Indices for the MQR disposal mound had a major mode at the +5 class interval (Figure 3-53). These values were significantly less than the new CLIS reference station (Mann-Whitney U test; $p < 0.001$) and from those measured in the August 1985 survey ($p = 0.004$). In fact, the mean OSI value for the MQR mound was the lowest of any of the 11 disposal mounds surveyed in 1986 (5.58 ± 2.59). This largely reflects the relatively thin RPD values and the presence of methane at three station replicates. In addition, despite the apparent increase in colonization by Stage III taxa, the majority of photographs (69%) showed Stage I seres as predominant. The two low indices at station 600N (-1 and -3; Figure 3-57) are apparently related to local surface disturbance (Figure 3-58).

The major change in the MQR mound in 1986 relative to 1985 was the appearance of Stage III seres at most stations (13 out of 17). This was significant because the MQR disposal mound has historically experienced the slowest rate of colonization compared with other CLIS disposal mounds. It is unclear if the appearance of Stage III taxa represents larval colonization or passive transport of adults from the surrounding seafloor related to the passage of Hurricane Gloria in September 1985. Because well-developed feeding voids take several weeks to months to be produced by head-down deposit feeders, the post-hurricane survey of the MQR mound in October may have missed the evidence of their presence.

The mean apparent RPD depth appears to be significantly shallower in 1986 than in 1985. This may be related to developing hypoxia in Central Long Island Sound. In August 1986, a dissolved oxygen survey of the central Sound was conducted for EPA Region I by SAIC (SAIC, 1987). As part of this study, five polarigraphic electrode (YSI) measurements were made of dissolved oxygen at station Center at the MQR mound at a distance of one centimeter above the bottom. These values were 3.38, 2.42, 2.60, 2.60, and 2.56 mg/l. Five measurements were also obtained from the CLIS reference station on the same day (3.28, 2.60, 2.54, 2.46, 2.46 mg/l). <u>All</u> these values were within the hypoxic range and represent concentrations of less than half saturation. These data strongly suggest that dissolved oxygen concentrations should be measured routinely in all Long Island Sound DAMOS monitoring efforts in order to understand the year-to-year changes which are mapped with the REMOTS® system. The MQR mound still continues to lag behind the other disposal mounds in terms of infaunal colonization and sediment irrigation.

3.3.6 Norwalk (NOR) Mound

The major grain-size mode of silt-clay ($\geq$ 4 phi) remained unchanged at all stations from previous surveys. Most stations showed the presence of very fine, fine, and medium sand (in the 4-1 phi range) overlying disposed muds (Figure 3-59). Several stations also showed the presence of shell-lag deposits, and methane gas was present at station Center (Figure 3-59). Disposed material was apparent at stations near the center of the grid (Figure 3-59). In the August 1985 survey, over half of the station replicates showed evidence of reduced sediment at the surface; this was attributed to biogenic activity. The present survey did not reveal extensive surface deposits of reduced sediment. An exception to this was station 200W (Figure 3-60), where low reflectance sediment had filled-in a depression on the bottom. It is likely that this low reflectance sediment was derived from macrofaunal burrow excavation activities.

The frequency distribution of small-scale boundary roughness (Figure 3-61) showed that most values fall within the 0.4 to 0.8 cm classes, with a sample mean of 0.73 cm ± 0.29 cm. These values were not significantly different from those measured in August 1985 ($p = 0.68$).

The frequency distribution of mean apparent RPD depths showed major modes shared between the 3 and 4 cm class intervals (Figure 3-61), with a sample mean of 3.15 cm ± 0.94 cm. These values were significantly shallower than those measured in August 1985 ($p < 0.05$, Mann-Whitney U-test). Low values were found at stations 200W, 400W, 200SW, 200E, 400E, and 600E (Figure 3-62).

Stage III infaunal assemblages dominated the area, with only stations Center, 200S, and 200SE being dominated by Stage I seres (Figure 3-63). The generally high successional status has remained the same since the last survey in August 1985; stations 200S and 200SE were dominated by a Stage I assemblage during this earlier survey also. This apparent lack of colonization by Stage III taxa at these two stations may reflect either natural variability in their distribution or unfavorable physical/chemical sediment conditions which are localized and not readily inferred from the REMOTS® photographs.

The Organism-Sediment Index values were predominately greater than +7 (overall mean of +8.3), which means that the overall area had a relatively high habitat quality as measured by this parameter (Figure 3-61). The 1986 OSI values were not significantly different from those obtained in either the August 1985 survey or at the new CLIS reference station. However, in comparison with the August 1985 survey, fewer stations were encountered with a + 11 OSI value. The mapped distribution of OSI values shows that values less than +7 were clustered around the center of the mound (Figure 3-64).

In August 1986, SAIC made six measurements of dissolved oxygen at this disposal point with a polarigraphic electrode (YSI) at a height of 15 to 16 cm above the bottom (SAIC, 1987). These values were all within the hypoxic range (1.88, 1.90, 2.40, 1.84, 1.80, 1.76 mg/l) and indicated that oxygen stress may be occurring in this region of the Sound during the summer. Future measurements of dissolved oxygen are recommended to evaluate this potentially important ecological factor.

3.3.7 New Haven 74 (NH-74) Mound

The major modal grain-size in this area remained unchanged (≥ 4 phi) since the September 1984 REMOTS® survey. A diffuse surface sand component was detected at some stations, but it appeared to be highly diluted with the silt-clay fraction in most instances. Station Center had a very thin surface sand layer and showed indications of recent erosion (Figure 3-65). This mound was capped with sand in 1973, before routine monitoring which might have provided an estimate of the original cap thickness. It is possible that the sand cap may have been largely homogenized within the mound apex. This may be the long-term result of sedimentation of fines and mixing of the sand with underlying ambient sediment and dredged material as a result of bioturbation. It is also quite possible that a portion of the sand cap could have been removed by short-term sediment transport, particularly as a result of Hurricane Gloria. It should be noted that it at the time of the July 1986 survey, 13 years had elapsed since the original disposal and capping event. It might be expected that the "optical signature" of the cap as seen in the REMOTS® photographs would be lost over this time period due to the processes mentioned above.

Apparent dredged material was observed at all stations except 600S (Figure 3-66). Disposed material may have been present at this station at one time, but it could no longer be distinguished.

The frequency distribution of small-scale boundary roughness had a major mode at the 0.8 cm class interval (Figure 3-67; sample mean = 0.72 ± 0.42). This compares with a major mode of 0.4 cm measured in the August 1985 survey, although statistically the two sets of values were not significantly different ($p = 0.60$). The slightly higher boundary roughness values found during the present survey were apparently produced by local physical or biogenic disturbance of the sediment surface.

The major modal apparent RPD depth fell within the 4 cm class interval (Figure 3-67), with a sample mean of 3.41 cm ± 0.95 cm. Station Center had an anomalously thin RPD (0.79 cm) apparently due to surface erosion at the mound apex as a result of Hurricane Gloria (Figure 3-68). In the August 1985 survey, station Center had a deep RPD (4.34 cm), but measurements from the adjacent station (200W) were very shallow (0.88 cm). RPD depths at NH-74 were not significantly different from those measured in August 1985.

Half of the stations surveyed appeared to be in a Stage I sere and half in a Stage III sere (Figure 3-69). More stations appeared to be in a low-order successional stage than measured in August 1985. Results from the 1985 survey (based on an analysis of three replicates per station) showed four stations in a Stage I sere: 200E, 200W, 400W, and 200SE. The present results were based on the analysis of only one replicate per station, so within-station variability could not be evaluated.

The distribution of OSI values was distinctly bimodal (Figure 3-67). Eight stations were in a high successional status with relatively deep RPD values (OSI= 10 to 11). The remaining stations were clustered between +4 to +7. This bimodality was also present in the August 1985 survey, and the OSI values were not significantly different between these two surveys. Direct station comparisons show, however, that station Center in 1985 had an OSI of +11. This dropped to -1 in this survey (Figure 3-70) due to surface erosion at the mound apex (Figure 3-65). Surface erosion at NH74 station Center was estimated to have been approximately 3.55 cm from 1985 and 1986 by comparison of mean RPD's at the apex of the mound.

3.3.8 New Haven 83 (NH-83) Mound

The major modal grain-size of the New Haven 83 mound fell within the silt-clay fraction ($\geq$ 4 phi). Several stations showed the presence of a subordinate sand mode in the upper surface layers (very fine sand, fine sand and medium sand; Figure 3-71). Disposed material was found at all stations except 600N, 400S, and 600E; at most stations, it exceeded the camera prism penetration depth.

In the August 1985 survey, 60% of the station replicates showed the presence of reduced sediment at the surface. This was attributed to the intensive foraging activity of large epifaunal organisms. Five stations in the present survey showed the presence of reduced sediment at or near the sediment-water interface (Figure 3-71). However, this reduced sediment occured on a much smaller scale compared with the August 1985 results and was probably related to infaunal bioturbation activity rather than epifaunal foraging.

The major mode of small-scale boundary roughness fell within the 0.8 cm class interval (Figure 3-72; sample mean = 1.09 ± 0.78 cm.). These values were significantly greater than those measured in August 1985 ($p < 0.05$, Mann-Whitney U-test). The increase in small-scale boundary roughness was potentially related to the physical disturbance of the area as a result of Hurricane Gloria.

The mean apparent RPD depth frequency distribution (Figure 3-72) showed that most values fell within the 2 to 3 cm class intervals, with an overall mean value of 2.63 ± 0.98 cm. These did not differ significantly from RPD measurements in August 1985 ($p = 0.5512$), but they were significantly lower than values at the new CLIS reference station ($p < 0.01$, Mann-Whitney U-test). Given the normally-expected sequence of infaunal colonization and increased bioturbation, it would seem likely that the RPD depth (which is comparatively shallow) should increase in this area. The lack of a significant increase in RPD depth at the NH-83 mound between August 1985 and July 1986 may indicate that infaunal colonization is not proceeding at a normal rate. However, it should be noted that erosion of surface layers (approximately the top 2-3 cm) associated with Hurricane Gloria probably caused the RPD to become more shallow between the two surveys (SAIC, 1989a). This would also explain the observed results. The areal distribution of RPD values showed no clear spatial trends (Figure 3-73). Station Center had a comparatively deep RPD and showed no evidence of erosion such as shell or sand lag deposits, suggesting that the mound apex is physically stable.

The distribution of infaunal successional assemblages showed a patchy mosaic of Stage I, II, and III seres (Figure 3-74). Stage I seres dominated (11 of 17 stations), which could suggest an aberrant rate of colonization or simply reflect the lack of replication. Thepresence of Stage III seres at station Center, however, support the interpretation of the mound apex being stable. Tubicolous amphipods (probably Ampelisca sp.) were present in low abundance at station 400N.

The frequency distribution of OSI values was skewed toward lower values, with the major mode in the +5 class interval (Figure 3-72). The mean OSI value was 5.86 ± 1.75. OSI values at this mound were significantly lower than the new CLIS reference station ($p < 0.001$), and only the MQR mound had a lower mean value. OSI values have not changed significantly at this mound since August 1985. The spatial distribution of values was somewhat patchy, with stations north and south of the mound center having higher OSI values than stations on the eastern and western flanks (Figure 3-75).

3.3.9 CLIS-86 Mound

Recently-disposed dredged material was apparent at all stations except 400N, 600N, 200SW, and 600S (Figure 3-76). The boundary of the deposit could not be determined (i.e., contoured) accurately because dredged material extended in several directions beyond the area covered by the REMOTS® grid. Generally, the CLIS-86 mound appeared to have an irregular, elliptical "footprint" with a north-south radius of 350 to 400 meters and an east-west radius greater than 600 meters (Figure 3-76).

The major modal grain-size at the CLIS-86 mound fell within the silt-clay ($\geq$ 4 phi) size class. Stations located within 200 to 400 meters of the center also had a very fine, fine, and medium sand subordinate mode in the near-surface layers (Figure 3-76). The centers (topographic high) of many of the CLIS disposal mounds have developed shell and sand "lag" deposits over time, related to the washing of fines from the sediment as the tidal stream moves over the mound. There was no evidence as yet of a lag deposit at the CLIS-86 station Center.

The major mode for small-scale boundary roughness fell within the 0.8 cm class interval (Figure 3-77), with a mean value of 0.86 cm ± 0.31 cm. The origin of this roughness appears to have been a combination of biogenic and physically-produced microtopography.

The histogram of the mean apparent RPD depths at this mound showed the major mode shared between the 3 and 4 cm classes (Figure

3-77), with a mean value of 3.20 cm ± 0.89 cm. These were not significantly different from the new CLIS reference station. The mapped distribution shows that biogenic mixing apparently has been successful in "ventilating" the sediment following disposal, with the exception of stations 600W and 200SE (Figure 3-78). The latter station had a thin layer of low reflectance sediment overlying high reflectance sediment (Figure 3-79).

Half of the stations had Stage III seres present (Figure 3-80). Stations which were in a low-order stage of succession included station Center to 600E, station 200N, 200NW, and 200SW. This was roughly the area which showed the thinnest apparent RPD (i.e., biogenic mixing) depths (Figure 3-78). These results suggest that the CLIS 86 mound was being colonized successfully, with infaunal irrigation of the sediment helping to depress the mean apparent RPD to a depth of over 3 cm at most of the stations having Stage III organisms present. The data must be interpreted with care; however, as past experience has shown that the successional status of disposed materials during initial post-disposal monitoring surveys is typically highly variable within a station. These results are based on analysis of only one station replicate.

The frequency distribution of OSI values showed a range of values from +4 to +11 with a major mode at +5 (Figure 3-77). This was not unexpected, given the recent disposal, early stages of colonization, and the fact that some of the stations were located on the ambient seafloor (Figure 3-81). Stations located on dredged material at this mound had a mean OSI value of 7.29 ± 2.64. These values were significantly different from the new CLIS reference station ($p = 0.0272$, Mann-Whitney U-test).

3.4 REMOTS® Sediment-Profile Surveys at Ghost Sites 1 and 2

3.4.1 Ghost Site-1 (GHOST-1)

The major modal grain-size at all stations was silt-clay ($\geq$ 4 phi). Sand-over-mud stratigraphy was present at 4 stations (Figure 3-82). Direct physical evidence of disposed material (e.g., a buried oxidized sedimentary horizon, chaotic sedimentary fabrics, methanogenic sediments) was not apparent in any of the photographs from this survey.

The frequency distribution of small-scale boundary roughness showed a major mode at 0.8 cm, with a mean value of 0.89 cm ± 0.51 cm (Figure 3-83). This topography was imparted by a smooth yet undulating bottom surface. Biogenic features such as tube structures, burrows, and fecal pellet layers dominated this surface. In general, high boundary roughness may reflect disposal surfaces which have been progressively smoothed by currents and bioturbation. However, these data alone are not sufficient to identify dredged material, and as indicated above, there was no direct physical evidence of either recent or relict dredged material in the photographs from the site.

The frequency distribution of mean apparent RPD depth showed a major mode at the 4 cm class interval (mean RPD depth = 3.86 cm ± 0.72cm; Figure 3-83). These values were significantly greater than those from the new CLIS reference station ($p < 0.05$, Mann-Whitney U-test). The areal distribution of RPD values showed that mean apparent RPD depths were generally uniformly deep (Figure 3-82). Two small areas exist where RPD values were less than 3 cm.; stations B1 and C1 fell within this shallow redox area and also had high boundary roughness values. Station G1, which had a relatively thin RPD, also had sand-over-mud stratigraphy. Based on physical criteria alone, these stations are potential locations where "errant dumps" may have occurred during the original disposal operation of Black Rock Harbor materials at the FVP mound.

The map of successional stage (Figure 3-84) showed a patchy mosaic of Stage I, Stage I-III and Stage III assemblages. The absence of replicate photographs did not allow an evaluation of within-station variation. However, if this map is an adequate characterization of successional status, than stations D1 and G1 (Stage I seres) also had thin RPD values, and station G1 showed sand-over-mud stratigraphy. These REMOTS® parameters suggest that these stations might have experienced disturbance in the recent past, however, there was no evidence in the side-scan records to support this possiblity (see section 3.2).

The Organism-Sediment Index frequency distribution was bimodal, with a major mode at +11 and a minor mode at +7 (Figure 3-83); the mean OSI value for this area was high (9.15 ± 1.98). OSI values were not significantly different from those measured at the new CLIS reference station. In our past REMOTS® work associated with monitoring disposal mounds in central Long Island Sound, we found that OSI values of +6 or less indicated recently disturbed environments. This disturbance could be related to disposal activities or natural events such as bottom erosion or predation. The areal distribution of OSI values showed four locations with values equal to or less than +6 (Figure 3-85).

3.4.2 Ghost Site-2 (GHOST-2)

The sediment grain-size major mode at all the Ghost Site-2 stations was silt-clay ($\geq$ 4 phi). Fourteen stations showed a minor mode of sand within the surface layers (Figure 3-86). It is unclear if this sand component was related to past disposal events or, as previously mentioned, to the onshore to offshore transport of sand related to Hurricane Gloria. No other clear evidence of exotic (i.e., disposed) materials was present (e.g., buried redox layers, chaotic fabrics, highly reducing sediments at depth, methanogenic sediments).

The small-scale boundary roughness frequency distribution showed a major mode in the 0.8 cm class interval (Figure 3-87), with a mean value of 1.04 ± 0.49 cm. These values were comparatively high, but inspection of the photographs showed that this was related to both bioturbation and the presence of a smooth yet undulating surface which was probably natural for this area.

The mean apparent RPD depth frequency distribution had a major mode at the 4 cm class interval (Figure 3-87); the mean value was 3.71 cm ± 0.68 cm. The mapped distribution of RPD depths (Figure 3-86) showed the area to be generally characterized by values which were significantly higher than the new CLIS reference station ($p < 0.05$, Mann-Whitney U-test). However, an area where apparent RPD depths were less than 3 cm was identified (Figure 3-86). Stations A2 and B3 fell within this area; both had sand-over-mud stratigraphy and small-scale boundary roughness that was greater than 1 centimeter. Station C4, which likewise had high boundary roughness, was also located within this area. These physical parameters could be indicative of the presence of relict dredged material, although the lack of direct evidence in the photographs and the absence of evidence of past disturbance in the side-scan records makes this unlikely.

The map of successional seres (Figure 3-88) showed a large area containing only Stage I taxa extending from the northeast corner to the south side of the area surveyed. This may reflect natural patchiness in the distribution of Stage III organisms, but the scale of such variablity is difficult to assess. Obtaining several replicate photographs per station would have enabled an assessment of small-scale patchiness, but in the Ghost Site surveys such replication necessarily was sacrificed for greater spatial coverage. It is interesting to note that the area of shallow RPD values did not fall within the patch of Stage I seres.

The Organism-Sediment Index frequency distribution (Figure 3-87) was bimodal, with a major mode at +11 and minor modes at +10 and +7. Past work indicats that areas with OSI values of +6 or less have undergone recent disturbance, due to either disposal operations or natural factors such as erosion or predation. The mean OSI value for this area (8.96 ± 1.89) was relatively high; these values were not significantly different from those at the new CLIS reference station. Stations 5C, 7E and a cluster of four stations in the NE quadrant of the area surveyed had OSI values of +6 or less (Figure 3-89). Of these, stations F2 and E7 had sand-over-mud stratigraphy, and station G2 had high boundary roughness.

3.5 Sediment Chemical Analysis

The results of the sediment chemical analyses of the Top and Bottom sections of the cores from the replicate grab samples were presented for each disposal mound and the reference station (Tables 3-1 through 3-19). In the case of PCBs, only one composite sample was analyzed from each station. With the exception of Hg at Norwalk Center (Table 3-9), mean concentrations were at 'Moderate' levels or lower for all mound and reference stations sampled, compared to the New England River Basin Commission's (NERBC) interim criteria (NERBC, 1980). At Norwalk Center, both Top and Bottom core section samples exceeded the 1.5 ppm upper limit for 'Moderate' levels of Hg, because of particularly high concentrations detected in one individual replicate (2.44 ppm in one Top replicate and 4.15 ppm in one Bottom replicate). However, both Top and Bottom samples at this station had at least one replicate with Hg results below the 'Moderate' upper limit.

'Low' levels or lower were detected for all parameters at CLIS reference, CS-1 Center, CS-2 Center, STNH-S Center, and most of the STNH-N stations. At STNH-N stations 100N, 200N, and 400E, 'Moderate' levels of Hg were detected in Top and/or Bottom samples, and 'Moderate' levels of Pb where detected in the Bottom sample of station 200E. At FVP Center, MQR Center, CLIS-86 Center, NH74 Center and Norwalk Center, levels of Hg, Pb, Zn, Cr, Cu and PCBs generally fell within the 'Moderate' category in both Top and Bottom samples. (The State of Connecticut doesn't have a classification for PCBs; however Massachusetts has values of <0.5 for 'Low'; 0.5-1.0 for 'Moderate'; and >1.0 for 'High'). All the other metal and PCB concentrations at these stations were at 'Low' levels.

Statistical comparisons revealed that for most parameters at most of the stations sampled there was no significant difference between levels detected in the Top and Bottom core sections (Table 3-20). The exceptions included MQR Center, STNH-S Center, and NH74 Center, which showed significantly greater elevations in the Bottom samples for some of the trace metals and percent total carbon. At STNH-N Center, concentrations of Pb, As, and Fe were significantly elevated in the Top of the core section (Table 3-20).

In comparisons of the Top 2 cm samples, every parameter tested was significantly elevated at MQR compared to the reference station (Table 3-21). FVP, CLIS-86, NH74 and Norwalk showed levels elevated from reference for approximately half of the parameters tested, while the other mounds showed only a scattering of parameters with levels elevated from reference (Table 3-21). Statistics for the Bottom core section samples more clearly identified MQR, FVP, and NH74 to be mounds consistently elevated from reference in all or almost all parameters tested. NH-83, Norwalk, and CLIS-86 also showed significantly greater concentrations than reference in many of the trace metals, total carbon, and oil and grease. The rest of the mounds again showed only a few parameters with levels elevated from reference (Table 3-22).

The % total organic carbon, % total nitrogen, and % total hydrogen data were not tested statistically because these parameters generally follow the % total carbon data. Unlike these other parameters, the % total carbon data showed the best replication and was consistently above the detection limits, therefore providing better information. The % total carbon levels in the Botttom core section samples were consistently elevated above reference levels for all the mounds except CS-2 and STNH-N, where levels were either not significantly different or were significantly less than reference (Table 3-22).

PCB concentrations could not be tested statistically because only single composite samples were analyzed at each station. However, as already indicated, none of the mounds exceeded the NERBC 'Moderate' upper limit for PCB's of 1.0 ppm. The highest PCB concentrations were detected at the FVP, MQR, CLIS-86, NH74, and Norwalk mounds, where average concentrations ranged from 0.33 to 0.86 ppm. This compared to the 0.06 ppm PCB's detected at the reference station (Tables 3-1 through 3-19). The rest of the mounds ranged from 0.04 to 0.15 ppm PCB's, essentially within the range detected at the reference station, and well below the 0.5 ppm upper limit for NERBC 'Low'.

Concentrations of most parameters at the eight stations sampled around the STNH-N disposal mound were not statistically different from the concentrations at station Center (Table 3-23). Stations 100S and 100N did show significantly lower concentrations compared to Center for most of the trace metals in the Top 2 cm samples. COD levels were consistently higher than at the Center station for both Top and Bottom samples from 400W, 150W, 200E, 400E, and 200N. Levels of Cr and Cu were consistently higher at these same stations in Bottom samples, and Pb was elevated in both Top and Bottom samples from 150W and 200E (Table 3-23). However, the magnitudes of the differences between the Center station and the outlying mound stations were not large. More importantly, there did not appear to be any consistent trends in chemical concentrations with distance from the STNH-N Center station.

Statistical comparisons between the concentrations measured in the Top and Bottom core sections from the STNH-N stations also showed few significant differences (Table 3-24). At a few of the stations, the levels of one or two parameters were higher in the bottom sections, particularly at station 200E for Pb, Zn, Cu, and oil and grease. Cu at station 100S, and Pb, As, and Fe at the Center station had significantly lower levels in the Bottom core section samples.

Statistical comparisons were also made between the 1986 data set and the results of chemical analyses of samples collected from stations in the vicinity of the STNH-N disposal mound in 1982 and 1984 (Tables 3-25 and 3-26). These tests did show some apparent trends with time. For stations 400W, 400E and 100S, several of the trace metals showed significantly higher concentrations in 1982 compared to 1986. The Center station, 150W, 100N and 250S showed no change from 1982 to 1986, and stations 200E and 200N showed significantly higher concentrations in 1986 compared to 1982 (Table 3-26). Comparisons between the 1984 and 1986 results did not comfirm any of these patterns except in the case of station 200E, where the 1986 concentrations were still significantly higher than the 1984 levels for several trace metals.

3.6 Benthic Community Analysis

The visual descriptions of sediment samples collected for benthic community analysis indicated various grain sizes occurring at each disposal mound (Table 3-27). Fine sand was found at STNH-N and CS-2 as a result of the capping operations conducted there. The oily silt-gravel mixture found at CLIS-86 was the result of recent disposal operations.

In the list of species found in each area sampled (Table 3-28), family names were included only when they provided information on included species. As an example, opisthobranch gastropods in three families were listed together rather than in three parts of the table.

The sieve residues from the CLIS reference samples contained the shells of Mulinia and Nucula, fine organic detritus, and a small amount of yellow sand. FVP Center samples contained gray sand with mica, coarse terrestrial plant debris, and shells of estuarine species. Oil contaminated the FVP material. The MQR samples contained a small volume of fine plant debris. The STNH-N samples contained a large volume of sand and estuarine shells.

The total number of species and individuals in major taxonomic groups in each sample was recorded (located at the end of Table 3-28). The average number of individuals per sample and the total number of species per station were: 100 and 20 for MQR Center, 487 and 37 for FVP Center, 2053 and 35 for CLIS reference, and 4268 and 42 for STNH-N Center.

Although these four stations are at similar depths and within a few miles of each other, there were large differences in the grain size and contamination level of the sediment at each station. Detailed knowledge of station histories would be necessary to reach conclusions concerning the progress of faunal recolonization and the relative sensitivity of community components.

Samples from MQR Center contained the fewest species and individuals of any station. The dominant species, M. ambiseta, N. incisa, and M. cristata, are members of the normal CLIS silt/clay assemblage. The large numbers of the bivalves Mulinia and Nucula found at the CLIS reference station were conspicuously absent. In the absence of pollution-indicating species, some physical cause of low abundance must be hypothesized.

3.7 Body Burden Analysis

Triplicate analyses were conducted on Nephtys incisa collected from the reference, STNH-N, FVP, and MQR stations. Only a single sample was available from the CLIS-86 mound. These samples were analyzed for eight inorganic elements and reported on a dry weight basis (Table 3-29), as well as on a wet weight basis (Table 3-30). Samples were also analyzed for several PCB formulations (Table 3-31).

Statistical analyses (Kruskal-Wallis) were conducted on the results to test for concentration differences between organisms collected from the disposal mounds and those collected from the reference station (Table 3-32). PCB concentrations could not be tested statistically because all of the samples showed concentrations below the analytical detection limits. Also, the CLIS-86 data could not be tested because only a single sample was available from that location.

The results from statistical analyses of the inorganic data showed that the concentrations of Cr, Cu, and Zn were significantly elevated ($p<0.05$) in Nephtys collected from the STNH-N station compared to levels in organisms collected from the reference station. The concentrations of As and Pb were significantly lower in the STNH-N polychaetes compared to those from the reference station.

The concentrations of Cr, Cu, and Pb were significantly higher in the Nephtys from FVP compared to levels in organisms collected from the reference station. The same three elements also showed significantly higher concentrations in Nephtys collected from MQR.

4.0 DISCUSSION

4.1 Topographic Changes and Disposal Mound Stability at CLIS

One objective of the 1986 field operations was to delineate the extent and topography of the dredged material deposit resulting from disposal during the 1985-86 season. The bathymetric survey showed a significant accumulation of dredged material at the buoy in the northwest corner of the site. The new CLIS-86 mound, which had a maximum thickness of 2 meters, occurred slightly east of the buoy at a depth of approximately 16.4 meters. Based on changes in depth, the radius of the mound was determined to be about 250 meters.

The exact boundary of the area covered by recently-deposited dredged material could not be determined based on the REMOTS® photographs because the coverage provided by the REMOTS® station grid was limited. The REMOTS® results did indicate that the new mound had a north-south radius of about 350 to 400 meters and an east-west radius greater than 600 meters, which is larger than the radius indicated by the bathymetry results (Figure 3-76). This is mainly because of the camera's ability to detect thin layers on the flanks of the deposit. Such layers were below the limits of detection by precision bathymetry and were therefore unaccounted for in the volume difference calculation. As a conservative estimate, it was calculated that the mound flank occupied an area of approximately 527,200 m^2. Assuming an average dredged material thickness of 10 cm in this area, which is again a conservative estimate, results in a volume of 52,720 m^3 of material on the mound flanks not accounted for in the bathymetric depth difference calculation. Adding this to the depth difference volume of 79,200 m^3 results in a final total of 131,920 m^3 of dredged material detected on the bottom using the combined techniques.

The final total volume estimate of 131,920 more closely approaches, but remains less than, the scow log volume estimate of 164,045 m^3 of disposed material. There are several reasons for the discrepancy. First, the volume estimate of material on the mound flank based on REMOTS® was very conservative, in terms of both the areal extent of the material and its thickness. It is likely that additional material which was not accounted for by either REMOTS® or bathymetry occurred beyond the area covered by the REMOTS® station grid. Second, the scow log estimate was derived from the drafts of the loaded scows, which typically hold a large volume of water collected with the dredged material. This leads to an overestimation of the total amount of material. In addition, the effects of the loss of interstitial water from the dredged material during descent and compaction of the material on the bottom will cause the depth difference to be less than the scow log volume estimate.

Another objective of the bathymetric surveys at CLIS was to assess the stability of past disposal mounds. Direct comparison of the topography at each of the past disposal mounds surveyed did not detect any significant changes in depth that could be attributed to any particular process (erosion, consolidation, etc.). This was not unexpected since surveys conducted after Hurricane Gloria in October 1985 revealed only local redistribution of sediment, and no storms of the same magnitude occurred since the surveys.

4.2 Ghost Site 1 and 2 Investigations

Another objective of the 1986 monitoring efforts was to examine the Ghost Site 1 and 2 areas, located outside the disposal site boundaries, for the presence of dredged material. Examination of the side scan records from GHOST-2 revealed small areas with high reflectance and the presence of a sunken scow, but did not detect an area large enough to indicate the quantity of material (50,000 m^3) allegedly disposed. Likewise, analysis of the bathymetric data did not indicate any distinct changes in depth that could have been caused by dredged material disposal. Due to the location of GHOST-2, it is possible that some dredged material fell from scows on their way to or from another disposal location inside CLIS. There was indirect evidence in the Ghost-2 REMOTS® photographs that the area might have received dredged material at some time in the past. Examples of such evidence include sand-over-mud stratigraphy, high boundary roughness, thin RPD's, highly-reduced sediment at depth, chaotic sedimentary cross-sectional texture, Stage I seres, and OSI values less than +6. However, there was no consistent and unequivocal REMOTS® evidence indicating that disposed materials existed in this area. If disposed materials were present, they were deposited several years ago or, if more recent, the deposited materials were very thinly dispersed (i.e., much thinner than the present mean bioturbation depth). In either case, there was no optical "signature" to provide conclusive evidence of disposal as detectable by REMOTS® photography. The overall area appeared to have high benthic habitat quality not significantly different from the new CLIS reference station.

Examination of both the bathymetric and side scan records from GHOST-1 also did not detect any features to indicate the presence of dredged material. Although gradients in certain REMOTS® parameters were seen at Ghost-1, direct physical evidence of disposed material (e.g., anomalous sediment type, chaotic fabrics, methanogenic sediments) likewise did not exist. The REMOTS® OSI parameters mapped at Ghost-1 suggested, but did not prove, that recent disturbances had affected stations D1, E1, G1, and perhaps B2, B3, and B6. However, there were no indications that this disturbance was caused by recent dredged material disposal. Since disposal during the 1985-86 season took place in the western portion of CLIS, it is unlikely that a scow would be so off course to have disposed of material at GHOST-1. Like Ghost Site 2, this area appeared to have a high benthic habitat quality as measured by various REMOTS® parameters, and it was comparable to the new CLIS reference station.

4.3 Benthic Habitat Quality at the CLIS Disposal Mounds and the New Reference Station

The REMOTS® surveys also were conducted to provide an assessment of benthic recolonization and overall habitat conditions at each disposal mound, as well as determine the suitability of the new CLIS reference station. Summary statistics for the ten CLIS disposal mounds, the new CLIS reference station and the GHOST-1 and GHOST-2 sites surveyed in July 1986 (Table 4-1) showed that the new CLIS reference station had a higher mean OSI value (9.55) than any of the disposal mounds surveyed. Such a relatively high OSI value would be expected in areas of the seafloor which was not been affected by disturbance (e.g., dredged material disposal, erosion, predator foraging, near-bottom hypoxia, etc.). Because it did not appear to have been affected by dredged material disposal, the new reference area should serve as an adequate representative of the ambient seafloor and should therefore be a valid control station for future monitoring at the disposal site.

The rank-order position of the highest-ranked disposal mound (STNH-N), based on the average OSI values at the REMOTS® stations having dredged material present (i.e., "mound" stations), remained the same between August 1985 and July 1986 (Table 4-1). The OSI values at the STNH-N, FVP, NH-74, Norwalk, and CS-2 disposal mounds, as well as those at the GHOST-1 and GHOST-2 areas, were not significantly different from the OSI values at the new CLIS reference station for either the stations located on dredged material of for stations on the edge or flanks of these mounds. The OSI values for stations located on dredged material at the MQR, NH-83, CLIS-86, STNH-S and CS-1 mounds were significantly lower than those at the reference station. In addition, "edge and ambient" stations at STNH-S also had significantly lower OSI values than the reference station (Table 4-1).

The three disposal mounds that consistently have had low mean OSI values (MQR, NH-83 and STNH-S) are located along the southern border of the CLIS Disposal Site in approximately 65 feet of water. In August 1986, SAIC measured dissolved oxygen from Throgs Neck Bridge to the area off New Haven, including MQR station Center, the old CLIS reference station, and a station in 126 feet of water just north of Port Jefferson (SAIC, 1987). All of these stations had hypoxic water (less than 3 mg/l dissolved oxygen); in fact, this hypoxic water extended all the way to Throgs Neck. Extension of this hypoxic water eastward of the CLIS Disposal Site remains undocumented. In addition, it is not known how far north of the MQR mound this hypoxic water spread. In any event, it is quite possible that this seasonal hypoxia, which had its greatest effect in the deepest part of the Sound, contributed to the low OSI values of the deeper mounds. Dissolved oxygen levels were also measured over the WLIS Disposal Site in August 1986. Values fell below 2 mg/l, and the mean OSI for the WLIS site (as measured in August 1986) was low (5.8), (SAIC, 1987).

The role of seasonal hypoxia in structuring the biology, biogenic mixing depths, depths of the mean apparent RPD, and Organism Sediment Indices is unknown. The recent discovery of regional hypoxia in the central Sound has cast a new light on the DAMOS monitoring protocol. It appears imperative to add near-bottom dissolved oxygen measurements to all REMOTS® measurements and to do hydrographic profiling (CTD/DO profiles) of the water column to relate water column stratification to hypoxic water thickness whenever possible. This would provide documentation of the spatial extent of hypoxic near-bottom water relative to REMOTS® benthic analyses at and near the disposal sites.

The MQR mound continued to have one of the slowest rates of benthic ecosystem recovery among the mounds at the CLIS site; this phenomenon has been noted in past REMOTS® surveys. Results from the sediment chemistry analyses (Tables 3-21 and 3-22) showed this mound to be the <u>only</u> mound with significantly elevated levels of <u>all</u> contaminants measured as compared with the reference station. The relatively higher levels of chemical contamination combined with the potential hypoxia effects could both contribute to the slow rate of infaunal succession documented at this location.

As previously indicated, there was no definitive evidence of disposed material in either Ghost Site 1 or 2. Both areas had average OSI values close to +9 and were not significantly different from the new CLIS reference station (Table 4-1). If material was disposed in these areas in the past, three possibilities exist: 1) REMOTS® sampling stations (spaced at 100 m intervals) were not located on this material; 2) the material was disposed a long time ago, and subsequent colonization and reworking has caused the material to converge in its biological and physical properties with the ambient seafloor; or 3) small volumes of material from any recent disposal activities were spread out in thin layers, so that the ambient infauna were able to rework the material into the bottom, erasing its "optical signature".

After a period of 13 years, the sand cap on the New Haven-74 disposal mound could no longer be seen as a discrete sedimentary layer. The sand has been mixed with fine-grained sediment, leaving the sand fraction as only a minor textural component. It seems reasonable to assume that distinct features of sand or mud caps (e.g., irregular sediment fabrics, layers having distinct grain-size and/or optical reflectance, etc.) which are thin relative to the bioturbation depth of Stage III taxa would be short-lived, due to sediment reworking by these organisms. The upper 20 cm of the sand cap at CS-2, after only 3 years, has also been thoroughly mixed with fine-grained sediment. The only station to show clear evidence of the sand cap in the upper sedimentary layer was located at 600N (CS-1).

The July 1986 REMOTS® sample size at the CLIS mounds was reduced by one third from that taken in August 1985. Although three replicate photographs were obtained at each station, only one replicate was analyzed. This reduced data base has tended to compromise the statistical comparison of the different disposal mounds between years. In particular, it was difficult to evaluate within-station patchiness in the occurrence of Stage III taxa, so that apparent changes in successional stage between 1985 and 1986 could not be determined adequately. Analysis of only one replicate photograph allowed a greater number of stations to be sampled, thus increasing spatial coverage of the different disposal mounds while sacrificing the assessment of small-scale variability. In order to insure statistical integrity between surveys, it is recommended that all future REMOTS® monitoring at the CLIS site be based on an analysis of a minimum of three station replicates.

4.4 Sediment Chemical Analysis

Another objective of the July 1986 field operations was to determine the concentrations of selected chemical constituents in sediments from each of the ten disposal mounds and the new reference station. It is instructive to compare the results of the chemical analyses with other studies which have reported the concentrations of metals and PCBs in Long Island Sound sediments (Table 4-2). Benninger et al. (1979) measured the concentrations of Zn, Cu, and Pb in a sediment core collected in Central Long Island Sound. The Zn and Cu concentrations detected in the top 10 cm of the sediment core were comparable, or slightly higher than the reference levels found in the present study (Table 4-2). However, the Pb concentrations reported by Benninger et al. (1979) were lower than those found at the reference station in the present study.

Greig et al. (1977) measured the concentrations of a suite of trace metals in the top four cm of sediment at stations throughout Long Island Sound. In his study, sediments in the vicinity of the new CLIS reference station showed similar, or slightly higher concentrations of Zn, Cu, Cr, and Hg compared with the results of the present study (Table 4-2). As in comparisons with Benninger et al., Pb concentrations were lower than those found in the present study at the reference station. Cd levels were below the analytical detection limit in both Greig's and the present study; however, his detection limits were considerably lower. Similarly, the levels of Ni measured by Grieg were below the 28 ppm detection limit in the present study (Table 4-2).

This above observations are consistent with data from Munns et al. (in press), who reported lower concentrations of Pb and higher concentrations of Zn, Cu, and Cr for CLIS reference station samples. The levels of Cd and Ni detected by Munns were lower than the detection limits of the present study, while percent total carbon and PCBs were within the range measured in the present study (Table 4-2). At the FVP mound, Munns et al. reported concentration ranges in 1985 samples which overlapped with those in the present study for all parameters tested except PCBs, which appeared to be higher in July 1986 (Table 4-2). However, the PCB concentrations at the FVP Center station actually were quite variable in the Munns study and ranged as high as 1.8 ppm, above the mean value reported in the present study. For many of the other parameters measured in both studies, larger sample sizes in the Munns study could account in part for the wider range of concentrations reported.

The FVP mound had the highest concentrations of Cu and Cr compared to all the other CLIS mounds sampled in the present study (Table 4-2). The highest contaminant concentrations measured in individual samples occurred at the CLIS-86 mound for Pb, Zn, Cu, and Ni. A comparison of the present results at this mound with those from August 1985 indicated that the levels of Pb, Zn, As, Cu and PCBs were higher in the 1986 samples. These results are most readily attributed to the ongoing disposal at this mound, involving sediment from a number of different sources.

The former CLIS reference station was sampled during August 1985, September 1984, December 1983 and July 1983. Comparisons of these data with the July 1986 results from the new CLIS reference station did not reveal any large differences or temporal trends in the concentrations of any of the parameters measured. The FVP Center station was sampled during July and August 1983. Data for samples collected at this station were somewhat variable; however, for several parameters a trend of decreasing concentrations with time was evident. This was particularly true for Zn, As, Cd, Cr, Cu, % total carbon, chemical oxygen demand and oil and grease. This might reflect the increased oxidation of the disposed material with time, as well as some "dilution" of the material both from deposition and mixing with underlying sediments as a result of bioturbation. None of the parameters measured showed higher concentrations in the 1986 samples compared to the earlier results.

Sampling was previously performed at the MQR mound during October 1985 and September 1984. Chemical concentrations measured during all three sampling periods were relatively high at this mound. However, there were no major concentration changes noted in the samples collected between 1984 and 1986. Comparisons of results from the STNH-N Center station from October 1985, September 1984 and August 1983 showed Hg concentrations were higher in the samples collected during August 1983. The samples collected on the other two dates and in the present study showed lower and relatively consistent Hg levels. None of the other parameters showed major changes in concentration over the period sampled.

As previously noted, none of the sediment chemistry results of the present study exceeded NERBC 'Moderate' upper limits, except for Hg in the Norwalk Center sample, which fell within the 'High' category of high contamination. Several of the mounds were in the 'Low' range for all parameters tested. Those that showed a predominance of 'Moderate' contaminant levels were mounds which have received relatively contaminated dredged material (FVP, CLIS-86, NH74, and, to a lesser extent, Norwalk). These mounds were not capped and thus they do not show any "dilution" effects in their sediment chemistry as a result of capping with cleaner material. In comparison, the four capped mounds (CS-1, CS-2, STNH-N, and STNH-S) had levels within the 'Low' category for all parameters tested, suggesting that the caps have been effective in isolating or possibly "diluting" contaminated dredged material with cleaner sediment.

For most of the mounds sampled, no statistically significant differences were found for contaminent concentrations between Top and Bottom core sections (Table 3-20). However, MQR, STNH-S and NH74 did show significantly greater concentrations in the Bottom samples for some of the trace metals and percent total carbon. In contrast, STNH-N Center showed a number of parameters (Pb, As and Fe) to be significantly greater in the Top core section sample. This was the only station that showed significantly less % total carbon than the reference station in the Bottom sample (Table 3-22). In addition, this station also had the highest mean RPD (4.64 cm) of all the disposal mounds sampled. In a natural depositional system, trace metal distributions with depth are controlled by the redox potential of the sediment, as well as the supply of Fe and carbon (Benninger et al., 19XX). Such variables can help explain the observed results; however, the geochemical system involved is complex and a study designed specifically with these processes in mind would be required in order to assess their role in controlling contaminent concentrations with depth at specific disposal mounds.

The sediment chemistry results for the transect of stations sampled at STNH-N suggest that dredged material may have reached some of the outlying stations as part of the original disposal operation (Tables 3-10 through 3-18). However, statistical tests between the chemical results on these stations and the Center showed no indication of systematic transport in a specific direction (Table 3-23). If transport of contaminanted sediment from the Center to the outlying stations had occurred, a decreasing concentration gradient at stations along the axis of transport would be expected. This pattern was not observed in the present results.

It is important to recall that STNH-N is a capped mound consisting of sand from New Haven Harbor overlying material from Stamford, CT. Previous profiles of this mound showed the cap layer with steep topography, ranging from a thickness of approximately

3.5 m at the center to layers less than about 20 centimeters thick beyond a radius of about 150 to 200 meters (SAIC, 1980). Cap thickness also varied in different places on the mound. This suggests that the original cap layer could have been relatively thin at some of the outlying stations which showed contaminant concentrations above levels detected at the Center station in the present study. Bioturbation in these areas could have resulted in mixing of underlying contaminated sediments with the cap material, thereby elevating contaminant concentrations in surface sediments above those measured at stations such as the , where cap material alone was sampled. The fact that STNH-N had the deepest RPDs and a relatively high percentage of Stage III organisms compared to the other CLIS mounds gives strength to this interpretation.

Comparisons of data from samples collected at stations in the vicinity of the STNH-N disposal mound in 1982 and 1984 did show some apparent trends with time (Table 3-26). The most striking trend was the consistency in statistical results for Top and Bottom samples at individual stations: when 1982 or 1984 results were significantly different from the 1986 results, this was generally true for both the Top and Bottom samples. However, no systematic patterns beyond the individual station were apparent. It is therefore difficult to attribute the increases at station 200E from 1982 and 1984 to 1986 to transport of dredged material. Localized washing of the mound could account for some changes from year to year at individual stations. However, there were very few significant differences in concentrations at the mound apex (station Center), where such washing presumably occurs with greater frequency and/or intensity.

4.5 Benthic Community Analysis

Another objective of the 1986 field operations was to analyze the benthic community structure at selected disposal mounds and the new CLIS reference station. The faunal assemblage recovered at the CLIS reference station was similar to that found at the same location in the EPA/COE Field Verification Program. That long-term study showed that many of the dominant species go through irregular cycles of abundance. Since Mulinia is one of the most variable species, it is likely that the mature specimens found in the July samples may be absent in future samples. Dominance was shared by a large number of polychaete and mollusc species, while crustaceans were relatively uncommon, presumably because of the negative effects of high water content, fine-grained sediment.

Benthic community analyses were performed at the FVP mound because it had long-term data for comparison. Despite the presence of sand and shells in the FVP Center samples, most of the species recovered were ones adapted for soft bottoms. The number of species was similar to that found at the reference station (37 at FVP Center vs. 35 at the reference station), but numbers of individuals were much less (average 487 vs. 2053). A number of species also present at other mounds are indicators of high organic content or pollution (Oligochaeta, Mediomastus, Cossura, Polydora). Some species may have been absent from FVP Center because of some undetected negative effect. The bivalves Mulinia and Nucula and the polychaetes Paraonis and Melinna were much less abundant at FVP Center than at the reference station. The polychaetes Pherusa and Sigambra were found in both sand at STNH-N and silt/clay at CLIS reference, but not in the mixed sediment at FVP Center.

Benthic community analyses were conducted at the STNH-N mound because it had a different grain-size than the surrounding bottom. The STNH-N Center fauna was dominated by tube-dwelling polychaetes. These included suspension feeders such as Polydora and Spiophanes, and deposit feeding ampharetids, terebellids, and maldanids. Species which have a strong association with sandy bottoms included the polychaete Spiophanes, the bivalves Tellina and Ensis, and the amphipods Unciola and Leptocheirus. Species not seen in previous studies at the CLIS disposal site included the burrowing mud shrimp Callianassa atlantica and the polychaete Ancistrosyllis groenlandica.

The results from the benthic infaunal community analyses confirmed the infaunal successional stage designations made independently during analysis of the REMOTS® photographs. Of the three disposal mounds sampled for detailed infaunal analyses, STNH-N station Center had the greatest infaunal numerical abundance and species richness. All the replicate REMOTS® photographs from STNH-N Center showed a particularly dense Stage III-I assemblage; taxonomic identification confirmed the presence of numerous surface suspension-feeders and grazers (Polydora, Spiophanes, Tellina, Ensis) as well as subsurface deposit-feeders (e.g., maldanid polychaetes). The new CLIS reference station (also given a Stage III-I designation in the REMOTS® analysis) also was dominated by deposit-feeders (Nucula, Yoldia, Euclymene, Asychis) with the suspension-feeding mactrid bivalve Mulinia lateralis present in fairly high abundance. Of the three replicate REMOTS® photographs from the FVP Center, two received a Stage I designation and one received a Stage III-I designation, indicating small-scale spatial heterogeneity with infaunal taxa. Results of the infaunal analyses showed the Stage I taxa Mediomastus, Cossura, and oligochaetes as dominants along with the Stage III taxon Nephtys. MQR, the most faunally depauperate mound of all CLIS areas surveyed with REMOTS® also had the lowest abundance and species richness from the grab analyses; all replicate REMOTS® photographs analyzed from the MQR Center showed a Stage I successional assemblage, and the presence of Stage III organisms on the MQR mound was documented for the first time. Results from the benthic infaunal analyses confirmed the presence of Stage I taxa as dominants (Mediomastus, Melinna) and also the presence of Stage III taxa (Nephtys, Euclymene).

The rank order of these four mounds based on REMOTS® OSI values was comparable to the species richness results from the infaunal community analyses (Table 4-3). The new CLIS reference station, STNH-N mound, and FVP mound were essentially similar in terms of mean OSI rank and species richness, showing no statistically significant difference among these three areas for these two parameters. However, MQR did stand out as having significantly lower mean OSI and species richness values (Figure 4-3). The combined results of the REMOTS® analysis, the benthic infaunal community analyses, and the sediment chemistry analysis all suggest that extremely stressed conditions still existed at the MQR mound in July 1986.

4.6 Body Burden Analysis

A final objective of the 1986 field operations was to assess the relationship between sediment contaminant levels and bioaccumulation at the FVP, MQR, STNH-N, and CLIS-86 disposal mounds. At the MQR and FVP mounds (both uncapped), Cr and Cu levels were elevated both in the sediment and in the collected Nephtys. These results suggest some correlation between sediment contaminant levels and bioaccumulation. However, at the STNH-N mound the elevated concentrations of Cr, Cu, and Zn in Nephtys did not correspond with elevated sediment concentrations of these three metals. Concentrations in the sediment at this mound were generally the same or lower than those in the sediment collected at the reference station. Only Hg sediment concentrations were elevated at STNH-N; however, this contaminant was not elevated in Nephtys collected there. The sand cap at this mound could have resulted in either dilution or isolation of contaminants in the underlying disposed material to the extent that elevated concentrations were not measured in the sediment grab samples obtained. However, the observed elevated levels of Cr, Cu, and Zn in the collected Nephtys imply that complete "biological isolation" may not have been achieved. The polychaetes which were sampled may possibly have been exposed to elevated contaminants in the underlying sediment in the process of vertical migration and head-down feeding.

One possible explanation for the anomalous benthic recolonization rates and different benthic community types documented in the past at the MQR mound compared to all the other CLIS mounds is bioaccumulation of inorganic metal contaminants. However, Cr, Cu and Pb also showed significantly higher concentrations in Nephtys collected at FVP, a mound which has experienced relatively high rates of colonization by Stage III infauna. Therefore, bioaccumulation of these three elements cannot alone serve to explain the lack of infaunalization at MQR. It is possible that metal contamination in combination with potential hypoxia effects could have adversely affected the rate of colonization at this mound, or that some other contaminant or combination of contaminants not analyzed for were responsible.

It is instructive to compare the results of the body burden analyses in the present study with those from other studies. The Fe concentrations reported for the present study ranged between 340 and 820 ppm dry weight, except for the CLIS-86 sample which showed a concentration of 8,600 ppm. The levels reported by Munns et al. (in press) were all between 600 and 1,000 ppm. The extremely high Fe levels found in the CLIS-86 Nephtys samples was probably due to the presence of sediment in the gut of these organisms. The levels of most other elements were also elevated in the CLIS-86 sample, probably due to the same reason. Therefore, the contaminant levels measured in the organisms from this station will not be discussed.

Lake et al. (1985) conducted a laboratory study on the bioaccumulation of several inorganic elements from Black Rock Harbor sediment, the material that was disposed at FVP. Their study measured the concentrations of Cr, Cu, Zn, Cd, and Fe in organisms exposed to sediment. The results showed that only Cr and Cu were significantly bioaccumulated from the sediments. Both of these elements as well as Pb showed elevated concentrations in the present study at FVP.

Munns et al. (1988) reported that Cr concentrations in Nephtys collected at the CLIS reference station ranged from 1-2 ppm dry weight. This is higher than the concentrations (0.20-0.30 ppm) found in Nephtys collected from the reference station in the present study (Tables 3-29 and 3-30), and similar to the levels reported on the FVP and MQR disposal mounds. Munns et al. (1988) reported concentrations between 2 and 5 ppm for Cr in Nephtys collected on dredged material at FVP.

For Cu, the range of concentrations reported here were 17-21 ppm for organisms from the reference station. Munns et al. (1988) reported levels of about 30 ppm from the reference station. Levels were highest in organisms from FVP in the present study, reaching about 50 ppm. Munns et al. (1988) also reported concentrations near 50 ppm on dredged material around FVP.

The Pb levels that Munns et al. (1988) reported for the CLIS reference station were about 3-4 ppm. On dredged material, Munns et al. measured Pb concentrations in Nephtys of about 7 ppm. In this study, the reference levels were about 3-4 ppm and about 8-10 ppm on the FVP and MQR disposal mounds.

Zn concentrations were about 180 ppm at the reference station and only slightly higher at 240 ppm in the mound samples. Munns et al. reported similar Zn concentrations ranging from 130-150 ppm dry weight at the reference station and about 200 ppm on dredged material. The Cd concentrations found at the reference station in the present study (0.58-1.1 ppm) were similar to the 1 to 3 ppm concentrations reported by Munns et al. for the reference station. Cd concentrations on dredged material in the present study (0.85-1.2 ppm) were not significantly increased over reference levels. This is similar to what was reported for Cd by Munns et al.

The PCB concentrations reported here for Nephtys were below the analytical detection limits for all samples (Table 3-31). These detection limits ranged from 270-770 ppb. The detection limits were generally higher than the concentrations previously measured by Munns et al. in Nephtys from the reference station (200-400 ppb).

The measured wet weight concentrations for Hg (Table 3-30) and PCBs (Table 3-31) were well below the FDA Alert Levels. These were the only compounds quantified for which Alert levels are presently being applied. The FDA Alert Levels are 0.2 ppm for Hg and 2 ppm for PCBs.

5.0 CONCLUSIONS

The only significant addition to the bathymetric features at CLIS was the development of the new CLIS-86 disposal mound, which had a maximum thickness of 2 meters and a radius of about 250 meters as detected with acoustic methods. The REMOTS® results showed that recently-deposited dredged material covered an area with a north-south radius of about 350 to 400 meters and an east-west radius in excess of 600 meters. An estimated 131,920 m^3 of disposed material was detected on the bottom using precision bathymetry and REMOTS® photography, compared to a scow log volume estimate of 164,045 m^3. No evidence of significant changes in topography at other mounds was detected.

The bathymetric and side scan surveys conducted at GHOST-1 and GHOST-2 outside the CLIS boundaries did not detect large enough areas of high reflectance or distinct changes in depth to account for the approximately 50,000 yd^3 of dredged material allegedly deposited in each area. Likewise, there was no conclusive evidence of dredged material in the REMOTS® photographs obtained in these two areas.

Based on REMOTS® parameters, the new CLIS reference station had higher mean OSI values than any of the disposal mounds which were surveyed. This new area appears to represent a valid reference station for future monitoring. Mean OSI values at the STNH-N, CS-2, FVP, NOR, and NH-74 disposal mounds, as well as those at Ghost Sites 1 and 2, were not significantly different from those measured at the new CLIS reference station. The three disposal mounds that consistently have exhibited relatively low mean OSI values (STNH-S, NH-83 and MQR) are located along the southern border of the CLIS Disposal Area. It is possible that hypoxic conditions previously documented in Long Island Sound by SAIC have adversely affected the benthic ecosystem at these mounds.

The MQR disposal mound continued to have one of the slowest rates of benthic ecosystem recovery among the mounds at CLIS, possibly the result of chemical contamination combined with hypoxic effects. After a period of 13 years, the sand cap at NH-74 was no longer apparent as a discrete sedimentary layer in the upper 10-15 cm of sediment. At the FVP mound, there was a deepening of RPD depths and a notable increase in the number of Stage III organisms relative to the post-Hurricane Gloria REMOTS® survey of November 1985.

In order to maintain the statistical integrity of the REMOTS® data base for the CLIS disposal site, it is recommended that all future REMOTS® monitoring be based an analysis of a minimum of three station replicates. Furthermore, in light of evidence which suggests that seasonal hypoxia in Long Island Sound may be affecting benthic conditions at the CLIS disposal site, it appears imperative to add near-bottom dissolved oxygen measurements to all future REMOTS® measurements and to perform hydrographic profiling (CTD/DO profiles) of the water column.

None of the sediment chemistry results exceeded NERBC 'Moderate' upper limits except for Hg in the Norwalk Center sample, which was at 'High' levels. Notably, the mounds that have been capped (CS-1, CS-2, STNH-S and STNH-N) almost all showed relatively low (i.e., 'Low') contaminant concentrations. The levels of most of the parameters measured were either not different or significantly lower than reference levels. This was true for both the Top and Bottom core sections. The same was also true for the additional stations sampled around the STNH-N disposal mound. This suggests that the caps have been effective in isolating or at least "diluting" contaminants which might have been elevated in the capped dredged material. At the STNH-N mound, there was no evidence to suggest that transport of contaminants from the mound center to outlying stations had occurred. Also, only minor differences were noted between the concentrations measured at the STNH-N stations in 1986 and the results from samples collected in 1984 and 1982.

Sediment contamination levels for several parameters were significantly elevated compared to reference levels at the FVP, MQR, CLIS-86, NH-74 and Norwalk disposal mounds. This reflects the fact that contaminants were elevated in the dredged material deposited at these mounds. At the new CLIS-86 mound, the concentrations of several metals and PCBs were higher in 1986 compared to 1985, reflecting the ongoing disposal at this mound involving sediment from a number of different sources. The FVP mound showed elevated concentrations for most parameters in the Bottom (2-10cm) sediment core sections. However, the Top sections

(0-2cm) contained lower concentrations for most contaminants; these concentrations also were significantly lower than those in core sections (0-10cm) collected at FVP in 1983. This might reflect increased dilution or oxidation of the disposed material as a result of bioturbation. As indicated, the MQR mound contained significantly elevated concentrations in both the Top and Bottom core sections for all of the parameters measured.

Several other investigators have reported the concentrations of relevant elements or compounds in Central Long Island Sound sediment samples from areas away from dredged material. In general, the concentrations that have been reported are very similar to those measured at the reference station in the present study. Also, Munns et al. (in press) sampled sediment on the FVP disposal mound over a period of several years. The contaminant concentrations they reported were generally higher than the levels detected in the present study.

The faunal assemblage at the CLIS reference station was similar to that found at the same location in the EPA/COE Field Verification Program. Most of the species recovered at the FVP Center station were ones adapted for soft bottoms. The STNH-N Center fauna was dominated by tube-dwelling polychaetes, and several species which have a strong association with sandy bottoms were also present at this mound. The results of the benthic community analysis generally confirmed the REMOTS® infaunal successional designations and OSI rankings of the various mounds. The new CLIS reference station, STNH-N mound, and FVP mound were essentially similar in terms of mean OSI rank and species richness, while the MQR mound had a significantly lower mean OSI and species richness.

At the MQR and FVP mounds, Cr and Cu levels were elevated above reference both in surface sediments and in the tissue of the polychaete, *Nephtys incisa*. These results suggest some correlation between sediment contaminant levels and bioaccumulation. In contrast, elevated concentrations of Cr, Cu, and Zn in *Nephtys* at the STNH-N mound did not correspond with elevated sediment levels of these three metals. The sand cap at this mound might have been effective in isolating or diluting the metal concentrations in the surface sediments, but the polychaetes could have been exposed to the metals in the underlying capped material as a result of vertical migration or head-down feeding. Bioaccumulation of inorganic contaminants is a possible explanation for the anomalous recolonization rates at the MQR mound. The fact that several metals were also elevated in *Nephtys* at FVP, a mound with relatively high rates of colonization, suggests that other factors might have influenced recolonization at MQR.

The concentrations of several elements in *Nephtys* at the various disposal mounds sampled in July 1986 were generally similar to or lower than those reported by Munns et al. (in press) for organisms collected on FVP dredged material. Body burden levels reported by Munns et al. for the former CLIS reference station generally were either greater than or similar to those found in _Nephtys_ both at the new CLIS reference station and the disposal mounds. Although PCBs could not be detected in any of the _Nephtys_ samples analyzed in the present study, the detection limits were all well below the FDA Action Level of 2 ppm wet weight. Likewise, the measured Hg concentrations were all well below the FDA Hg Action Level of 0.2 ppm wet weight.

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TABLE 2-1. SUMMARY OF REMOTS SURVEYS IN THE CLIS DISPOSAL SITE.

MOUND	MOST RECENT SURVEYS	NUMBER OF STATIONS IN SURVEY	GRID USED
FVP	Numerous times in 1983 and 1984.		
	March 1985	21	
	June 1985	21	
	Oct. 1985	21	
	July 1986	21	Cross*
STNH-N	Jan. 1983	9	Cross
	Aug. 1983	9	Cross
	Sept. 1984	9	Cross
	Aug. 1984	17	Cross
	Nov. 1985	10	Cross
	July 1986	17	Cross
STNH-S	(same dates as STNH-N)	17	Cross
CS-1 & CS-2	April 1983 (baseline)	11	Cross
	May 1983	11	Cross
	Aug. 1983	11	Cross
	Sept. 1984	11	Cross
	Aug. 1985	17	Cross
	Oct. 1985	10	Cross
	July 1986	17	Cross
MQR	Jan. 1983	13	Cross
	Aug. 1983	13	Cross
	Sept. 1984	13	Cross
	Aug. 1985	12	Orthogonal**
	Oct. 1985	10	Cross
	July 1986	17	Cross
NOR	Jan. 1983	9	Cross
	Sept. 1984	9	Cross
	Aug. 1985	17	Cross
	July 1986	17	Cross
NH-74	Sept. 1984		
	Aug. 1985	17	Cross
	July 1986	17	Cross
NH-83	Jan. 1984		
	Sept. 1984		
	Aug. 1985		
	July 1986	17	Cross

* Cross indicates stations located along regular N-S E-W transects.
** Orthogonal indicates a regular 6 X 6 sampling matrix.

Table 2-2. Replicate Analysis of _Pitar_ Samples And NRC Lobster Hepatopancreas Tissue To Determine Analytical Precision

(Concentrations in ug/g dry weight)

Sample		**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Pb**	**Zn**
Pitar on DM 3	--	--	--	--	--	0.051	--	--	
Pitar on DM 3	--	--	--	--	--	0.060	--	--	
Mean		--	--	--	--	--	0.055	--	--
RPD[1]		--	--	--	--	--	16.3	--	--
Pitar on DM 2	12	0.97	0.69	16	240	--	4.8	150	
Pitar on DM 2	12	0.97	0.73	16	240	--	4.3	150	
Mean		12	0.97	0.71	16	240	--	4.6	150
RPD		8	0	6	0	0	--	11	0
NRC Lobster Tissue	-1	25.1	25.3	2.34	415	197	0.326	12.6	164
	-2	27.6	25.8	2.18	406	191	0.301	9.85	164
	-3	27.6	24.9	2.95	399	184	0.281	8.22	158
	-4	26.6	26.2	2.21	412	188	0.29	10.0	159
Mean		26.7	25.6	2.42	408	190	0.300	10.2	161
Std. Dev.		1.18	0.57	0.36	7.1	5.5	0.02	1.8	3.2
RSD[2]		4.4	2.2	15	1.7	2.9	6.5	18	1.9
Certified NRC[3] Values		24.6	26.3	2.4	439	186	0.330	10.4	177
Std. Dev.		2.2	2.1	0.6	22	11	0.06	2.0	10
% Recovery		108	97	100	93	102	91	98	91

[1] RPD = Relative Percent Deviation.
[2] RSD = Relative Standard Deviation.
[3] Certified reference material distributed by the National Research Council of Canada.
--- Not applicable.

Table 3-1. Chemical analysis of sediment collected at FVP-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A Top	A Bottom	B Top	B Bottom	C Top	C Bottom	Mean Std.Dev. Top	Mean Std.Dev. Bottom
Hg ppm	0.18	0.47	0.57	0.38	0.36	0.44	0.37±0.16	0.43±0.4
Pb ppm	68	163	163	130	99	139	110±40	144±14
Zn ppm	104	272	271	251	202	214	110±4	246±24
As ppm	5.1	5.8	6.6	6.4	5.2	5.6	5.63±0.68	5.93±0.34
Cd ppm	*	*	*	4.0	*	*	---	---
Cr ppm	46	266	231	229	156	192	144±76	229±30
Cu ppm	62	529	525	528	374	417	320±193	369±16
ppm	*	36	33	*	*	*	---	---
Fe ppm	22200	20800	21100	19800	17600	20200	20300±1960	13600±9480
% Tot. Org. C	0.88	0.83	0.98	0.98	0.77	0.84	0.88±0.11	0.88±0.08
% Tot. Carbon	1.89	3.12	2.08	3.19	2.14	2.64	2.04±0.11	2.98±0.24
% Tot. Hydrogen	0.53	0.62	0.46	0.65	0.44	0.55	0.48±0.05	0.61±0.05
% Tot. Nitrogen	0.20	0.25	0.17	0.23	0.17	0.20	0.18±0.02	0.23±0.03
COD ppt[1]	80	55	48	67	28	29	52±21	50±16
Oil & Grease ppm	456	1744	1742	1330	1159	1228	1119±526	1434±223
Total PCB ppm[2]							0.82	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-2. Chemical analysis of sediment collected at MQR-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.43	0.84	0.48	0.67	0.52	0.61	0.48±0.04	0.71±0.10
Pb ppm	144	171	161	190	160	179	155±8	180±8
Zn ppm	286	341	326	362	325	357	312±19	353±9
As ppm	10.5	7.5	10.9	10.9	12.8	21.6	11.4±1.0	13.3±6.0
Cd ppm	*	*	5	*	5	*	---	---
Cr ppm	124	147	148	155	135	148	136±10	150±4
Cu ppm	185	238	237	259	231	261	218±23	206±73
Ni ppm	*	*	*	31	*	*	---	---
Fe ppm	28000	30000	31600	31000	29200	30000	29600±1500	30330±470
% Tot. Org. C	1.07	0.97	0.92	0.71	1.07	0.93	1.02±0.09	0.87±0.14
% Tot. Carbon	3.29	3.6	3.27	3.73	3.31	3.64	3.29±0.02	3.66±0.07
% Tot. Hydrogen	0.80	0.84	0.80	0.82	0.75	0.90	0.78±0.03	0.85±0.04
% Tot. Nitrogen	0.31	0.33	0.30	0.35	0.30	0.33	0.30±0.01	0.34±0.01
COD ppt[1]	70	70	84	110	93	82	82±95	87±17
Oil & Grease ppm	1181	1676	1624	1984	1756	2557	1520±246	2072±365
Total PCB ppm[2]							0.81	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-3. Chemical analysis of sediment collected at CLIS-86-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std.Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.27	0.23	0.22	0.21	0.28	0.23	0.26±0.03	0.22±0.01
Pb ppm	124	140	110	199	373	218	202±121	186±33
Zn ppm	231	744	190	327	241	237	221±22	436±221
As ppm	3.8	5.8	9.3	7.5	5.6	4.3	6.2±2.3	5.9±1.3
Cd ppm	*	*	*	*	*	4	---	---
Cr ppm	70	84	79	86	71	82	73±4	84±2
Cu ppm	132	514	336	178	138	184	202±95	222±129
Ni ppm	*	33	71	44	*	31	---	36±7
Fe ppm	23200	2780	23300	3170	26500	24500	24330±1530	10150±10150
% Tot. Org. C	0.78	0.85	0.88	0.81	0.98	0.78	0.88±0.10	0.81±0.04
% Tot. Carbon	2.65	2.62	2.75	3.26	2.72	3.04	2.71±0.04	2.47±0.94
% Tot. Hydrogen	0.60	0.67	0.68	0.65	0.65	0.72	0.64±0.04	0.68±0.04
% Tot. Nitrogen	0.28	0.26	0.28	0.28	0.29	0.34	0.28±0.01	0.29±0.04
COD ppt[1]	----	40	49	51	52	74	51±2	55±14
Oil & Grease ppm	543	624	302	612	288	709	378±117	648±43
Total PCB ppm[2]							0.71	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-4. Chemical analysis of sediment collected at STNH-S-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.14	0.33	0.18	0.25	0.14	0.27	0.15±0.02	0.28±0.03
Pb ppm	48	71	<22	69	58	61	43±15	67±4
Zn ppm	105	154	80	121	103	166	96±11	147±19
As ppm	4.7	5.7	4.9	4.6	6.4	6.7	5.7±0.6	5.7±0.9
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	40	66	<6	49	38	64	28±16	60±8
Cu ppm	51	96	18	70	56	85	42±17	54±27
Ni ppm	*	*	*	*	48	*	---	---
Fe ppm	21300	28200	<208	26200	18400	27500	13300±9340	27300±830
% Tot. Org. C	0.63	0.79	0.83	0.88	0.59	0.75	0.68±0.13	0.81±0.07
% Tot. Carbon	1.88	2.53	1.40	2.36	2.06	2.37	1.78±0.28	1.83±0.68
% Tot. Hydrogen	0.50	0.66	0.34	0.67	0.50	0.68	0.45±0.09	0.67±0.01
% Tot. Nitrogen	0.16	0.23	0.12	0.21	0.15	0.23	0.14±0.02	0.22±0.01
COD ppt[1]	30	42	24	34	38	45	31±6	40±5
Oil & Grease ppm	571	344	235	342	220	337	342±162	341±3
Total PCB ppm[2]							0.13	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable

Table 3-5. Chemical analysis of sediment collected at CS-1-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.19	0.15	0.13	0.18	0.16	0.15	0.16±0.02	0.16±0.01
Pb ppm	87	41	84	64	93	78	88±4	61±15
Zn ppm	111	75	124	78	119	102	118±5	85±12
As ppm	4.3	3.5	2.8	5.4	4.2	5.0	3.8±0.7	4.6±0.8
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	39	<25	30	29	40	39	36±5	31±6
Cu ppm	59	46	53	47	60	57	57±3	48±18
Ni ppm	*	*	*	*	*	51	---	---
Fe ppm	21000	21100	19900	18900	23100	23500	21330±1330	21170±1880
% Tot. Org. C	0.80	0.74	1.19	0.90	1.30	0.90	1.10±0.26	0.85±0.09
% Tot. Carbon	2.47	2.70	2.26	2.33	2.49	2.92	2.41±0.10	2.21±0.82
% Tot. Hydrogen	0.75	0.69	0.64	0.68	0.72	0.72	0.70±0.06	0.70±0.02
% Tot. Nitrogen	0.26	0.21	0.24	0.20	0.25	0.23	0.25±0.01	0.21±0.02
COD ppt[1]	32	52	42	38	41	61	38±4	50±9
Oil & Grease ppm	266	251	661	305	317	298	415±175	285±24
Total PCB ppm[2]							0.09	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.

Note: Top = top 2 cm of core.
Bottom = remainder of core.

* Below detection limit for most of the samples.

--- Not applicable.

Table 3-6. Chemical analysis of sediment collected at CS-2-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.18	0.27	0.17	0.12	0.16	0.12	0.17±0.01	0.17±0.07
Pb ppm	53	61	<21	21	87	40	54±27	41±16
Zn ppm	115	85	54	13	130	158	100±33	85±59
As ppm	1.2	5.1	<1.0	<1.0	1.5	2.2	1.2±0.2	2.8±1.7
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	40	<25	<25	<25	52	40	39±11	30±7
Cu ppm	47	37	<13	<13	58	37	39±19	33±15
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	17100	17600	5760	3040	23500	18700	15450±7340	13110±7140
% Tot. Org. C	1.40	1.35	0.48	0.14	---	1.65	0.94±0.65	1.05±0.80
% Tot. Carbon	1.98	2.01	0.48	0.19	2.29	1.78	1.58±0.79	1.39±0.74
% Tot. Hydrogen	0.59	0.57	0.16	<.10	0.66	0.54	0.47±0.27	0.40±0.26
% Tot. Nitrogen	0.22	0.20	<.10	<.10	0.25	0.17	0.19±0.08	0.16±0.05
COD ppt[1]	39	52	12	7	49	40	33±16	33±19
Oil & Grease ppm	242	326	119	65	294	276	218±73	222±113
Total PCB ppm[2]							0.05	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-7. Chemical analysis of sediment collected at NH74-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	1.07	0.36	0.30	0.59	0.48	0.49	0.62±0.33	0.48±0.09
Pb ppm	92	142	125	189	174	181	130±34	171±21
Zn ppm	140	263	210	445	362	370	237±93	359±75
As ppm	1.3	3.1	0.3	2.4	1.9	3.9	1.8±0.4	3.1±0.6
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	63	118	108	182	148	151	106±35	150±26
Cu ppm	90	211	189	288	221	229	167±56	181±71
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	19300	3200	19000	2540	23700	25200	20670±2150	24600±1000
% Tot. Org. C	0.52	<.04	0.59	0.64	<.04	0.41	0.38±0.30	0.36±0.30
% Tot. Carbon	2.42	2.78	2.16	3.85	3.90	3.82	2.83±0.77	2.82±1.00
% Tot. Hydrogen	0.62	0.66	0.51	0.82	0.76	0.91	0.63±0.13	0.80±0.13
% Tot. Nitrogen	0.22	0.23	0.17	0.32	0.30	0.33	0.23±0.07	0.29±0.06
COD ppt[1]	87	67	13	79	85	91	62±34	79±10
Oil & Grease ppm	473	993	878	2489	1477	1833	943±412	1772±612
Total PCB ppm[2]							0.86	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-8. Chemical analysis of sediment collected at NH83-Center, July 1986 (concentrations on a dry weight basis)

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.23	0.14	0.62	0.19	0.92	0.26	0.59±0.28	0.20±0.05
Pb ppm	63	90	68	92	55	104	62±5	95±6
Zn ppm	90	145	109	198	119	168	106±12	170±22
As ppm	4.8	<1.0	1.0	<1.0	<1.0	2.0	2.3±1.8	---
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	31	58	65	63	52	78	49±14	66±9
Cu ppm	50	82	64	88	51	99	55±6	62±27
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	14700	19900	16500	19800	13600	23300	14930±1200	21000±1630
% Tot. Org. C	0.82	0.71	0.80	0.66	0.87	0.95	0.83±0.04	0.77±0.16
% Tot. Carbon	1.44	2.65	2.19	2.16	1.96	2.65	1.86±0.31	1.90±0.71
% Tot. Hydrogen	0.35	0.73	0.56	0.57	0.37	0.67	0.43±0.12	0.66±0.08
% Tot. Nitrogen	0.12	0.28	0.23	0.20	0.13	0.26	0.16±0.06	0.25±0.04
COD ppt[1]	36	47	43	52	26	43	35±7	47±4
Oil & Grease ppm	239	299	268	348	118	425	208±65	351±60
Total PCB ppm[2]							0.15	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-9. Chemical analysis of sediment collected at NORWALK-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	2.44	1.47	1.69	4.15	1.03	0.91	1.72±0.58	2.18±1.41
Pb ppm	152	117	111	190	141	110	135±17	139±36
Zn ppm	236	207	164	287	200	183	200±29	226±44
As ppm	8.6	9.5	1.5	10.2	1.6	6.7	3.9±3.3	8.8±1.5
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	76	65	55	87	75	60	69±10	71±12
Cu ppm	144	112	93	170	122	101	120±21	110±41
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	21500	28400	20600	27300	23700	21800	21930±1300	25830±2890
% Tot., Org. C	1.08	1.03	1.33	1.33	0.91	1.18	1.11±0.21	1.18±0.15
% Tot. Carbon	3.48	3.44	2.79	3.70	3.07	2.42	3.11±0.28	2.79±1.02
% Tot. Hydrogen	0.86	0.79	0.62	0.86	0.78	0.54	0.75±0.12	0.73±0.17
% Tot. Nitrogen	0.30	0.26	0.24	0.31	0.28	0.22	0.27±0.03	0.26±0.05
COD ppt[1]	72	100	48	46	43	57	54±13	68±23
Oil & Grease ppm	790	453	363	377	418	438	524±190	423±33
Total PCB ppm[2]							0.33	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = Top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-10. Chemical analysis of sediment collected at STNH-N-Center, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.20	0.57	0.26	0.23	0.17	0.26	0.21±0.04	0.35±0.15
Pb ppm	41	26	29	22	73	28	48±19	25±2
Zn ppm	54	83	55	196	167	43	92±53	107±65
As ppm	3.8	2.6	3.0	2.1	11.0	1.4	5.9±3.6	2.0±0.5
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	18	<18	<18	<18	40	<18	25±10	---
Cu ppm	25	307	15	13	45	15	28±12	112±169
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	10500	7230	8220	6620	23400	7110	14040±6680	6990±260
% Tot. Org. C	0.44	0.25	0.28	0.32	0.75	0.31	0.49±0.24	0.29±0.04
% Tot. Carbon	0.88	0.54	0.57	0.75	2.09	0.72	1.18±0.66	0.67±0.09
% Tot. Hydrogen	0.23	0.15	0.14	0.18	0.55	0.17	0.31±0.22	0.17±0.02
% Tot. Nitrogen	<.10	<.10	<.10	<.10	0.21	<.10	---	---
COD ppt[1]	16	13	14	12	18	19	16±2	15±3
Oil & Grease ppm	69	262	69	55	231	65	123±76	127±95
Total PCB ppm[2]							0.04	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-11. Chemical analysis of sediment collected at STNH-N-400W, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.21	0.24	0.17	0.26	0.15	0.38	0.18±0.02	0.29±0.06
Pb ppm	65	50	83	58	57	63	68±11	57±5
Zn ppm	111	89	128	111	107	116	115±9	105±12
As ppm	5.2	4.1	5.1	5.3	4.2	8.2	4.8±0.4	4.7±0.2
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	36	27	40	33	30	40	35±4	33±5
Cu ppm	52	41	60	52	43	65	52±7	53±10
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	18000	14600	20300	16900	16400	17800	18230±1600	16430±1350
% Tot. Org. C	0.63	0.43	0.68	0.51	0.50	0.61	0.60±0.09	0.52±0.09
% Tot. Carbon	2.11	1.36	2.09	2.06	2.10	2.24	2.10±0.01	1.89±0.38
% Tot. Hydrogen	0.53	0.38	0.54	0.47	0.52	0.46	0.53±0.01	0.44±0.05
% Tot. Nitrogen	0.21	0.13	0.20	0.18	0.21	0.17	0.21±0.01	0.16±0.03
COD ppt[1]	38	29	47	38	33	34	39±6	34±4
Oil & Grease ppm	247	212	342	303	117	173	235±92	229±54
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-12. Chemical analysis of sediment collected at STNH-N-150W, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.40	0.32	0.19	0.89	0.19	0.37	0.26±0.10	0.53±0.26
Pb ppm	279	123	90	328	113	236	161±84	229±84
Zn ppm	250	183	126	459	134	348	170±57	297±118
As ppm	5.6	4.1	4.6	5.5	4.6	4.4	4.9±0.5	4.3±1.5
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	54	55	38	61	35	60	42±8	59±3
Cu ppm	135	92	58	221	59	124	84±36	146±55
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	16800	22100	17200	4280	15400	18900	16470±770	15090±7760
% Tot. Org. C	---	0.68	0.06	1.02	0.56	0.65	0.31±0.35	0.78±0.21
% Tot. Carbon	2.77	2.43	2.07	4.66	2.03	2.88	2.29±0.34	3.32±0.96
% Tot. Hydrogen	0.50	0.63	0.44	0.78	0.47	0.58	0.47±0.03	0.66±0.10
% Tot. Nitrogen	0.18	0.22	0.17	0.27	0.18	0.20	0.18±0.01	0.23±0.04
COD ppt[1]	52	28	37	79	45	49	45±6	52±21
Oil & Grease ppm	1220	426	337	2920	303	746	620±424	1364±1108
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-13. Chemical analysis of sediment collected at STNH-N-200E, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.41	0.19	0.72	0.16	0.35	0.56	0.49±0.16	0.30±0.18
Pb ppm	93	117	82	172	77	218	84±7	169±41
Zn ppm	121	158	100	152	105	197	109±9	169±20
As ppm	4.6	6.2	4.6	3.7	4.8	2.7	4.7±0.1	3.9±1.7
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	36	40	38	38	30	54	35±3	44±7
Cu ppm	53	86	43	81	44	116	47±4	94±15
Ni ppm	*	35	*	*	*	*	---	---
Fe ppm	16600	14100	15200	15500	14900	16700	15570±740	15430±1060
% Tot. Org C	0.55	0.48	0.72	0.44	0.57	0.03		
% Tot. Carbon	1.98	2.07	2.10	2.19	1.86	2.80	1.98±0.10	2.35±0.32
% Tot. Hydrogen	0.51	0.44	0.48	0.45	0.46	0.47		
% Tot. Nitrogen	0.20	0.17	0.18	0.14	0.18	0.16		
COD ppt[1]	25	36	30	30	34	45	30±4	37±6
Oil & Grease ppm	226	422	174	736	199	1056	200±21	738±259
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-14. Chemical analysis of sediment collected at STNH-N-400E, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.40	0.71	0.43	0.61	0.47	0.41	0.43±0.03	0.58±0.12
Pb ppm	52	86	81	51	79	25	71±13	54±25
Zn ppm	01	136	129	83	134	150	118±19	123±29
As ppm	5.5	6.1	6.3	7.6	8.2	6.1	6.7±1.1	5.9±2.0
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	47	48	40	26	48	<18	45±4	31±13
Cu ppm	44	66	72	39	65	81	60±12	62±17
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	23900	23000	20300	12100	23700	<66	22630±1650	11720±9370
% Tot. Org. C	0.70	1.02	0.84	0.65	0.58	0.06	0.72±0.13	0.58±0.48
% Tot. Carbon	2.24	2.13	2.43	2.24	2.42	2.22	2.36±0.09	2.20±0.05
% Tot. Hydrogen	0.64	0.60	0.61	0.59	0.62	0.62	0.62±0.02	0.60±0.02
% Tot. Nitrogen	0.24	0.21	0.24	0.22	0.23	0.21	0.24±0.01	0.21±0.01
COD ppt[1]	51	52	49	47	50	39	50±1	46±5
Oil & Grease ppm	335	227	375	194	321	487	344±23	303±131
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-15. Chemical analysis of sediment collected at STNH-N-200N, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.52	0.74	0.56	0.52	0.41	0.56	0.50±0.06	0.61±0.10
Pb ppm	82	84	70	105	63	99	72±8	96±9
Zn ppm	133	125	118	152	107	142	119±11	140±11
As ppm	5.7	4.2	5.4	7.8	4.8	9.4	5.3±0.4	5.4±2.5
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	47	47	33	51	36	49	39±6	49±2
Cu ppm	64	62	52	71	56	69	57±5	67±4
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	22200	22900	18200	23800	18200	22800	19530±1890	23100±360
% Tot. Org. C	0.52	0.36	0.61	0.45	0.60	0.85	0.58±0.05	0.55±0.26
% Tot. Carbon	2.41	2.04	1.97	2.21	2.28	2.36	2.20±0.18	2.20±0.13
% Tot. Hydrogen	0.62	0.54	0.45	0.59	0.57	0.59	0.55±0.09	0.57±0.03
% Tot. Nitrogen	0.24	0.22	0.17	0.23	0.23	0.21	0.21±0.04	0.22±0.01
COD ppt[1]	36	32	34	37	44	42	38±4	37±4
Oil & Grease ppm	291	359	109	340	261	347	220±80	349±8
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-16. Chemical analysis of sediment collected at STNH-N-100N, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.64	0.60	0.50	1.21	0.12	0.95	0.42±0.22	0.92±0.25
Pb ppm	<22	<22	25	94	25	22	24±1	46±34
Zn ppm	35	44	41	78	50	42	42±6	55±17
As ppm	1.7	1.9	1.9	3.1	1.4	1.8	1.7±0.2	1.7±0.7
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	<18	<18	<18	<18	<18	<18	---	---
Cu ppm	11	13	13	40	14	15	13±1	23±12
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	6550	4980	6870	8360	7150	6680	6860±250	6670±1380
% Tot. Org. C	0.24	0.28	0.28	0.28	0.22	0.17	0.25±0.03	0.24±0.06
% Tot. Carbon	0.44	0.46	0.50	1.05	0.56	0.83	0.50±0.05	0.78±0.24
% Tot. Hydrogen	0.12	0.11	0.12	0.17	0.15	0.17	0.13±0.02	0.15±0.03
% Tot. Nitrogen	<.10	<.10	<.10	<.10	<.10	<.10	---	---
COD ppt[1]	10	10	16	27	19	17	15±4	18±7
Oil & Grease ppm	42	44	56	487	72	69	57±12	200±203
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-17. Chemical analysis of sediment collected at STNH-N-100S, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.09	0.10	0.12	0.11	0.09	0.09	0.10±0.01	0.10±0.01
Pb ppm	<22	<22	28	<22	<22	25	24±3	23±1
Zn ppm	38	25	49	39	36	43	41±6	36±8
As ppm	1.2	1.3	1.8	2.3	1.5	2.1	1.5±0.2	1.5±0.6
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	<18	<18	<18	<18	<18	<18	---	---
Cu ppm	11	<10	22	<10	15	<10	16±5	---
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	6210	5580	9030	6450	6560	7480	7270±1260	6500±780
% Tot. Org. C	0.49	0.18	0.37	0.41	0.30	0.19	0.39±0.10	0.26±0.13
% Tot. Carbon	0.49	1.19	0.72	0.52	0.57	0.96	0.59±0.10	0.89±0.28
% Tot. Hydrogen	0.13	0.10	0.20	0.13	0.15	0.18	0.16±0.04	0.14±0.04
% Tot. Nitrogen	<.10	<.10	<.10	<.10	<.10	<.10	---	---
COD ppt[1]	11	12	14	7.7	10	17	12±2	12±4
Oil & Grease ppm	49	28	79	81	36	56	55±18	55±22
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.

Note: Top = top 2 cm of core.
Bottom = remainder of core.

* Below detection limit for most of the samples.

--- Not applicable.

Table 3-18. Chemical analysis of sediment collected at STNH-N-250S, July 1986 (concentrations on a dry weight basis).

Replicate	A		B		C		Mean (Std. Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.79	0.20	0.13	0.21	0.12	0.11	0.35±0.31	0.17±0.04
Pb ppm	43	45	60	81	70	72	58±11	66±15
Zn ppm	64	73	94	128	106	109	88±18	103±23
As ppm	3.1	0.9	4.4	5.0	4.5	5.0	4.0±0.6	3.4±1.6
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	22	44	33	46	39	39	31±7	43±3
Cu ppm	38	65	45	72	53	53	45±6	63±8
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	10400	11200	15600	18600	18900	18400	14970±3500	16070±3440
% Tot. Org. C	0.34	0.59	0.59	0.63	0.49	0.55	0.47±0.13	0.59±0.04
% Tot. Carbon	0.94	1.26	1.78	1.92	1.83	1.73	1.52±0.41	1.64±0.28
% Tot. Hydrogen	0.24	0.28	0.47	0.46	0.50	0.50	0.40±0.14	0.41±0.12
% Tot. Nitrogen	<.10	0.10	0.18	0.18	0.18	0.17	0.15±0.05	0.15±0.04
COD ppt[1]	30	14	36	42	43	24	36±5	27±12
Oil & Grease ppm	139	293	291	561	234	518	221±63	457±118
Total PCB ppm[2]							-----	
Total DDT ppm[2]							-----	

[1] Parts per thousand.
[2] Single analysis of combined core sections.

Note: Top = top 2 cm of core.
Bottom = remainder of core.

* Below detection limit for most of the samples.

--- Not applicable.

Table 3-19. Chemical analysis of sediment collected at CLIS-Reference, July 1986 (Concentrations on a dry weight basis).

Replicate	A		B		C		Mean	Std.Dev
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.09	0.08	0.10	0.12	0.14	0.09	0.11±0.02	0.10±0.02
Pb ppm	80	80	72	81	70	70	74±4	77±5
Zn ppm	105	122	111	118	114	101	110±4	114±92
As ppm	6.8	5.0	4.8	5.1	6.5	5.4	6.03±0.88	5.17±0.17
Cd ppm	*	*	*	*	*	*	---	---
Cr ppm	36	41	37	40	37	20	37±1	34±10
Cu ppm	37	44	42	43	37	33	39±2	40±5
Ni ppm	*	*	*	*	*	*	---	---
Fe ppm	24100	26600	25300	25500	24400	6110	24600±510	19400±9410
% Tot. Org. C	0.98	<.04	1.14	0.91	0.95	0.90	1.02±0.10	---
% Tot. Carbon	2.15	2.04	2.23	2.04	2.14	1.94	2.01±0.05	2.17±0.04
% Tot. Hydrogen	0.59	0.59	0.62	0.51	0.58	0.58	0.60±0.02	0.56±0.04
% Tot. Nitrogen	0.23	0.21	0.23	0.21	0.23	0.20	0.23±0.00	0.21±0.01
COD ppt[1]	44	---	47	54	34	34	42±6	44±10
Oil & Grease ppm	286	283	265	360	413	231	322±65	291±53
Total PCB ppm[2]							0.06	
Total DDT ppm[2]							<.02	

[1] Parts per thousand.
[2] Single analysis of combined core sections.
Note: Top = top 2 cm of core.
Bottom = remainder of core.
* Below detection limit for most of the samples.
--- Not applicable.

Table 3-20. Results of Statistical Testing for Significant Differences Between Core Sections From The CLIS Mounds July 1986

Variable	Ref	FVP	MOR	CL-86	STS	STN	CS-1	CS-2	NH74	NH83	NOR
Hg	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns
Pb	ns	ns	+	ns	+	-	-	ns	ns	+	ns
Zn	ns	+	+	ns	+	ns	-	ns	ns	+	ns
As	ns	ns	ns	ns	ns	-	ns	ns	+	ns	ns
Cr	ns	ns	ns	+	+	ns	ns	ns	ns	ns	ns
Cu	ns	ns	+	ns	+	ns	ns	ns	ns	+	ns
Fe	ns	ns	ns	ns	+	-	ns	ns	ns	+	ns
% Tot. C	-	+	+	ns	+	ns	ns	ns	ns	ns	ns
COD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Oil&Grease	ns	ns	ns	+	ns	ns	ns	ns	ns	+	ns

\+ = 2-10 cm core section is significantly greater than 0-2 cm section values, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.

\- = 2-10 cm core section is significantly less than 0-2 cm core section, $p \leq 0.05$.

ns = no significant difference, $p > 0.05$.

Table 3-21. Results of Statistical Testing for Significant Differences Between The Reference Station And CLIS Mounds, July 1986
0-2 cm Core Sections.

Variable	FVP	MQR	CL-86	STS	CS-1	CS-2	NH74	NH83	NOR	STN
Hg	+	+	+	ns	ns	+	+	+	+	+
Pb	ns	+	+	-	+	ns	+	-	+	ns
Zn	ns	+	+	ns	ns	ns	+	ns	+	ns
As	ns	+	ns	ns	-	-	-	ns	ns	ns
Cr	+	+	+	ns	ns	ns	-	ns	+	ns
Cu	+	+	+	ns	+	ns	+	+	+	ns
Fe	-	+	ns	-	-	-	-	-	-	-
% Tot. C	ns	+	+	-	+	ns	ns	ns	+	-
COD	ns	+	ns	ns	ns	ns	ns	ns	ns	-
Oil&Grease	+	+	ns	ns	ns	ns	+	ns	ns	-

\+ = significantly greater than Reference values, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.
\- = significantly less than Reference, $p \leq 0.05$.
ns = no significant difference, $p > 0.05$.

Table 3-22. Results of Statistical Testing for Significant Differences Between The Reference Station And CLIS Mounds, July 1986.
2-10 cm Core Sections

Variable	FVP	MQR	CL-86	STS	CS-1	CS-2	NH74	NH83	NOR	STN
Hg	+	+	+	+	+	ns	+	+	+	+
Pb	+	+	+	ns	ns	-	+	+	+	-
Zn	+	+	+	ns	ns	ns	+	+	+	ns
As	+	+	ns	ns	ns	ns	-	-	+	-
Cr	+	+	+	ns	ns	+	+	+	ns	
Cu	+	+	+	+	+	ns	+	+	+	ns
Fe	ns	+	ns	ns	ns	ns	ns	ns	ns	ns
% Tot. C	+	+	+	+	+	ns	+	+	+	-
COD	ns	+	ns	ns	ns	ns	+	ns	ns	ns
Oil&Grease	+	+	+	ns	ns	ns	+	ns	+	ns

+ = significantly greater than Reference values, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.
\- = significantly less than Reference, $p \leq 0.05$.
ns = no significant difference, $p > 0.05$.

Table 3-23. Results of Statistical Testing For Significant Differences Between Core Sections STNH-N Stations And The Center Station, July 1986

Variable	400W	150W	200E	400E	200N	100N	100S	250S
				Top				
Hg	ns	ns	+	+	+	ns	-	ns
Pb	ns	+	+	ns	ns	-	-	ns
Zn	ns	ns	ns	ns	ns	-	-	ns
As	ns	ns	ns	ns	ns	-	-	ns
Cr	ns	ns	ns	ns	ns	ns	+	ns
Cu	ns	ns	ns	ns	ns	ns	+	ns
Fe	ns	ns	ns	ns	ns	-	ns	ns
% Tot. C	ns	ns	ns	+	ns	-	ns	ns
COD	+	+	+	+	+	ns	ns	+
Oil&Grease	ns	+	ns	+	ns	ns	ns	ns
				Bottom				
Hg	ns	ns	ns	ns	ns	+	-	-
Pb	+	+	+	ns	+	ns	ns	+
Zn	ns	ns	ns	ns	ns	ns	ns	ns
As	+	+	+	+	+	ns	ns	ns
Cr	+	+	+	ns	+	bdl	bdl	+
Cu	ns	ns	ns	ns	ns	ns	-	ns
Fe	ns	ns	ns	ns	ns	-	ns	ns
% Tot. C	ns	ns	ns	+	ns	-	ns	ns
COD	+	+	+	+	+	ns	ns	+
Oil&Grease	ns	+	ns	+	ns	ns	ns	ns

\+ = station value is significantly greater than center station, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.
\- = significantly less than center station, $p \leq 0.05$.
ns = no significant difference, $p > 0.05$.
bdl= all samples below detection limit.

Table 3-24. Results of Statistical Testing for Significant Differences Between Core Sections From the STNH-N Mound, July 1986

Variable	CTR	400W	150W	200E	400E	200N	100N	100S	250S
Hg	ns	+	ns	ns	ns	ns	ns	ns	ns
Pb	-	ns	ns	+	ns	+	ns	ns	ns
Zn	ns	ns	ns	+	ns	ns	ns	ns	ns
As	-	ns	ns	ns	ns	ns	ns	ns	ns
Cr	ns	ns	+	ns	ns	ns	bdl	bdl	ns
Cu	ns	ns	ns	+	ns	ns	ns	-	ns
Fe	-	ns	ns	ns	ns	+	ns	ns	ns
% Tot. C	ns	ns	ns	ns	ns	ns	ns	ns	ns
COD	ns	ns	ns	ns	ns	ns	ns	ns	ns
Oil&Grease	ns	ns	ns	+	ns	ns	ns	ns	+

\+ = 2-10 cm core section is significantly greater than 0-2 cm section, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.

\- = significantly less than 0-2 cm section, $p \leq 0.05$.

ns = no significant difference, $p > 0.05$.

bdl= all samples below detection limit.

Table 3-25a. Chemical Analysis of Sediment Collected at the STNH-N Mound in January 1982

Location	% Vol Solids NED	Pb ppm	Zn ppm	Cr ppm	Cu ppm
400W-A	3.98	49	198	70	79
B	3.70	62	291	73	93
C	3.76	42	315	73	83
150W-A	1.90	96	170	44	60
B	3.23	216	336	106	106
C	1.80	45	150	43	43
CTR-A	0.80	58	160	58	66
B	0.40	*	48	*	21
C	0.50	*	63	*	*
200E-A	---	---	---	---	---
B	1.30	45	170	29	48
C	1.70	24	75	26	32
400E-A	3.70	64	160	58	72
B	3.20	40	160	58	75
C	4.10	52	170	56	68
REF-A	4.17	48	140	68	50
B	3.74	68	140	84	54
C	4.15	56	150	84	55

* Below minimum detection limit.
--- Not Applicable.

Table 3-25a Continued.

Location	% Vol Solids NED	Pb ppm	Zn ppm	Cr ppm	Cu ppm
200N-A	3.02	38	152	44	52
B	3.54	60	308	73	85
C	2.75	22	164	39	42
100N-A	0.50	22	110	*	21
B	0.50	*	38	*	9
C	1.07	*	165	*	11
CTR-A	0.80	58	160	58	66
B	0.40	*	48	*	21
C	0.50	*	63	*	*
100S-A	4.02	38	246	93	104
B	2.09	81	266	82	153
C	3.69	44	365	97	107
250S-A	2.57	34	239	43	40
B	2.30	94	300	71	116
C	2.59	15	96	34	35
REF-A	4.17	48	140	68	50
B	3.74	68	140	84	54
C	4.15	56	150	84	55

* Below minimum detection limit.
--- Not applicable.

Table 3-25b. Chemical analysis of sediment collected at STNH-N, September 1984 (concentrations on a dry weight basis)

STNH-N-CENTER

Replicate	**A**	**B**	**C**	Mean (Std. Dev.)
Hg ppm	0.29	*	0.12	---
Pb ppm	59	34	37	43±14
Zn ppm	66	48	117	77±36
As ppm	1.6	1.7	2.0	1.8±0.2
Cd ppm	*	7	*	---
Cr ppm	*	*	22	---
Cu ppm	14	16	21	17±4
Ni ppm	42	30	29	34±7
Fe ppm	4910	5560	7040	5840±1090
% Tot. Carbon	0.58	0.51	0.90	0.66±0.21
% Tot. Hydrogen	0.12	0.13	0.21	0.15±0.05
% Tot. Nitrogen	---	---	---	---
COD ppt[1]	19.9	14.4	13.5	15.9±3.5
Oil & Grease ppm	132	110	117	120±11

[1] Parts per thousand.
* Below detection limit.
--- Not applicable.

Table 3-25b continued.

STNH-N-200E

Replicate	A	B	C	Mean (Std. Dev.)
Hg ppm	0.20	0.09	0.15	0.15±0.06
Pb ppm	60	84	*	---
Zn ppm	161	196	198	185±21
As ppm	3.3	2.8	3.0	3.0±0.3
Cd ppm	*	*	*	---
Cr ppm	49	43	22	38±14
Cu ppm	51	46	244	40±14
Ni ppm	39	44	31	38±7
Fe ppm	15000	14900	8870	12920±3510
% Tot. Carbon	2.13	1.52	1.52	1.72±0.35
% Tot. Hydrogen	0.34	0.30	0.30	0.31±0.02
% Tot. Nitrogen	0.14	0.11	0.11	0.12±0.02
COD ppt[1]	30.3	35.4	31.0	32.2±2.8
Oil & Grease ppm	336	321	333	330±8

[1] Parts per thousand.
* Below detection limit.
--- Not applicable.

Table 3-25b continued.

		STNH-N-400E		
Replicate	A	B	C	Mean (Std. Dev.)
Hg ppm	0.09	0.25	0.26	0.20±0.10
Pb ppm	99	95	37	77±35
Zn ppm	278	156	202	212±62
As ppm	4.1	4.6	4.3	4.3±0.3
Cd ppm	*	*	*	---
Cr ppm	65	66	71	67±3
Cu ppm	58	58	69	62±6
Ni ppm	49	53	49	50±2
Fe ppm	22600	24600	23200	23470±1026
% Tot. Carbon	2.37	2.34	2.60	2.44±0.14
% Tot. Hydrogen	0.61	0.64	0.60	0.62±0.02
% Tot. Nitrogen	0.24	0.24	0.24	0.24
COD ppt[1]	57.4	64.3	52.8	58.2±5.8
Oil & Grease ppm	361	503	415	426±72

[1] Parts per thousand.
* Below detection limit.
--- Not applicable.

Table 3-26. Results of Statistical Testing for Significant Differences Between Core Sections From The STNH-N Mound In July 1986 And Grabs From January 1982 and September 1984.

Variable	CTR	400W	150W	200E	400E	200N	100N	100S	250S
January 1982									
Top									
Pb	ns	ns	ns	-	ns	-	ns	+	ns
Zn	ns	+	ns	ns	+	+	ns	+	ns
Cr	ns	+	ns	-	+	ns	bdl	bdl	ns
Cu	ns	+	ns	ns	ns	ns	ns	+	ns
Bottom									
Pb	ns	ns	ns	-	ns	-	ns	+	ns
Zn	ns	+	ns	ns	+	ns	ns	+	ns
Cr	ns	+	ns	-	+	ns	bdl	bdl	ns
Cu	ns	+	ns	-	ns	ns	ns	+	ns
September 1984									
Top									
Hg	ns			-	-				
Pb	ns			ns	ns				
Zn	ns			+	+				
As	-			-	-				
Cr	ns			ns	+				
Cu	ns			ns	ns				
Fe	-			ns	ns				
% Tot. C	ns			ns	ns				
COD	ns			ns	+				
Oil&Grease	ns			+	ns				
Bottom									
Hg	-			ns	-				
Pb	+			-	ns				
Zn	ns			ns	+				
As	ns			ns	-				
Cr	ns			ns	+				
Cu	ns			-	ns				
Fe	ns			ns	+				
% Tot. C	ns			ns	+				
COD	ns			ns	+				
Oil&Grease	ns			-	ns				

\+ = value is significantly greater than 1986 core section, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.

\- = value is significantly less than 1986 core section, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.

ns = no significant difference, $p > 0.05$.

bdl= all samples below detection limit.

Table 3-27. Visual Descriptions Of Biological Sediment Samples Collected At CLIS, July 1986

Station	Description
CLIS-86-1	1-2 cm redox layer over black, oily, gelatinous silty-gravel with shell hash underneath
CLIS-86-2	Same as above
CLIS-86-3	Same as above
CLIS-86-4	Same as above
CLIS-86-5	Same as above
FVP-1	1-2 cm oxidized layer over black sandy silt with petroleum odor.
FVP-2	Similar to above but more sandy and colonized by hermit crabs and tube worms.
FVP-3	Same as FVP-2
FVP-4	Same as FVP-2
FVP-5	Same as FVP-1
STNH-N-1	Silt/clay with fine sand on top, dense worm tube assemblage, sand throughout
STNH-N-2	Same as above
STNH-N-3	Same as above
STNH-N-4	Same as above
STNH-N-5	Same as above
MQR-1	Highly reduced silt/clay layer with strong H_2S odor, high water content
MQR-2	Same as above
MQR-3	Same as above
MQR-4	Same as above
MQR-5	Same as above
NH-74-1	5 cm layer of silty clay over medium sand, well developed redox, strong smell of H_2S
NH-74-2	6-7 cm layer of silty clay over black sand
NH-74-3	1 cm redox over 4-5 cm black sandy silt over shell hash,numerous hydroids
NH-74-4	1 cm oxidized layer over black gelatinous silt
NH-74-5	Same as NH-74-4
NH-83-1	thin (1 cm) redox, over cohesive black silty sand, well colonized with worm tubes
NH-83-2	Same as above
NH-83-3	Same as above
NH-83-4	Same as above
NH-83-5	Same as above

Table 3-27 continued.

NOR-1	1 cm oxidized layer over 5 cm black silty DM overlying gray clay
NOR-2	2 cm redox layer over 1 cm black silty DM over gray clay
NOR-3	1 cm oxidized layer over 3-4 cm black silty DM over gray clay
NOR-4	Same as NOR-3
NOR-5	Less than 1 cm oxidized layer over gray shelly sandy clay
STNH-S-1	1 cm redox layer with shell hash over gray and black sandy cohesive silt, H_2S odor
STNH-S-2	1-2 cm redox layer over 4-5 cm gray black sandy silt overlying silty shelly sand, H_2S odor
STNH-S-3	Same as STNH-S-1
STNH-S-4	Silty sand, high water content, no clumps, shell hash, some worm tubes
STNH-S-5	3 cm silty layer with shell hash over mix of gray clay, cohesive dry black silt, few worm tubes
CS-1-1	2 cm redox over mix of gray/black silt with clay clasts, worm tubes, mild H_2S odor
CS-1-2	Same as above
CS-1-3	Same as above
CS-1-4	Same as above
CS-1-5	Same as above except at 5-6 cm depth is shell hash layer
CS-2-1	5 cm redox layer of watery sand over soft clayey silt, worm tubes, gastropods
CS-2-2	Same as above with numerous worm tubes
CS-2-3	Same as CS-2-1 but more sandy
CS-2-4	Same as CS-2-3
CS-2-5	Same as CS-2-4 but more sandy
Reference-1	2 cm oxidized layer over gray cohesive silt, well colonized with worm tubes, shell hash
Reference-2	Same as above
Reference-3	Same as above
Reference-4	Same as above
Reference-5	Same as above

Table 3-28. Benthic Community Analysis For Samples Collected At Central Long Island Sound Disposal Site, July 1986

SPECIES	MQR CTR 1	MQR CTR 2	MQR CTR 3	FVP CTR 1	FVP CTR 4	FVP CTR 3	REFERENCE 1	REFERENCE 2	REFERENCE 3	STNH-N CTR 2	STNH-N CTR 3	STNH-N CTR 4
CNIDARIA												
Ceriantheopsis americanus	.	.	.	2	1	3	8	8	5	.	.	.
PLATYHELMENTHES sp.												
RHYNCHOCOELA												
Cerebratulus lacteus	.	.	.	.	.	.	.	.	.	1	2	2
Micura sp.	.	.	.	.	.	.	.	.	.	.	.	2
Tubulanus pellucidus	3	6	10	23	13	8	72	107	69	2	12	4
Rhychocoela sp.	.	.	.	.	1	.	.	.	.	4	.	.
PHORONIDA												
Phoronis muelleri	1	1	.	.	.	.	1	1	1	1	.	.
SIPUNCULA												
Phascolion strombi	.	.	.	.	.	1	.	.	.	.	.	.
ANNELIDA												
Oligochaeta spp.	3	1	3	83	28	8	20	33	21	4	.	8
Polychaeta												
Ampharetidae												
Ampharete arctica	.	.	.	.	1	5	.	.	.	52	12	52
Asabellides oculata	.	.	.	.	.	.	.	.	.	20	32	16
Melinna cristata	1	13	18	10	2	1	101	70	40	.	.	.
Arabellidae												
Drilonereis longa	.	.	.	.	.	.	.	.	.	.	1	.

Table 3-28 continued.

SPECIES	MQR CTR 1	MQR CTR 2	MQR CTR 3	FVP CTR 1	FVP CTR 4	FVP CTR 3	REFERENCE 1	REFERENCE 2	REFERENCE 3	STNH-N CTR 2	STNH-N CTR 3	STNH-N CTR 4
Capitellidae												
Mediomastus ambiseta	8	17	39	208	113	40	6	20	34	142	358	252
Chaetopteridae												
Spiochaetopterus oculatus	.	.	.	.	.	.	.	.	.	5	20	18
Cirratulidae												
Tharyx acutus	1	.	.	1	4	.	.	.	.	.	.	.
Cossura longocirrata	1	1	5	49	131	.	.	.	.	.	.	.
Flabelligeridae												
Pherusa affinis	.	.	.	.	.	.	11	15	12	19	25	8
Glyceridae												
Glycera americana	.	.	.	.	.	2	1	.	.	13	41	20
Hesionidae												
Podarke obscura	.	.	.	.	.	.	.	.	.	4	4	4
Lumbrineridae												
Lumbrineris tenuis	.	.	.	.	.	.	.	.	.	1	.	.
Ninoe nigripes	1	.	.	.	.	.	.	1	.	.	.	.
Maldanidae												
Asychis elongata	.	.	.	.	.	.	.	1	.	1	.	.
Euclymene zonalis	1	.	.	1	.	2	11	7	1	29	51	84
Nephtyidae												
Nephtys incisa	35	34	60	195	273	40	71	77	46	35	41	20
Oweniidae												
Owenia fusiformis	.	.	.	.	.	.	.	1	.	3	.	2

Table 3-28 continued.

SPECIES	MQR CTR 1	2	3	FVP CTR 1	4	3	REFERENCE 1	2	3	STNH-N CTR 2	3	4
Terebellidae												
Loimia medusa	.	.	.	.	.	.	.	.	.	10	20	8
Polycirrus eximius	.	.	.	.	.	3	.	.	.	40	86	66
MOLLUSCA												
Arcidae												
Anadara transversa	.	.	.	.	.	1	2	.	.	.	.	.
Lyonsiidae												
Lyonsia hyalina	.	.	.	.	.	2	.	.	.	.	.	.
Mactridae												
Mulinia lateralis	5	2	3	3	9	9	575	496	420	.	.	.
Nuculanidae												
Yoldia limatula	1	4	1	10	3	1	5	14	28	.	.	.
Nuculidae												
Nucula annulata	.	.	.	.	.	.	1255	1326	350	1	.	.
Pandoridae												
Pandora gouldiana	.	.	1	1	.	.	5	4	.	.	.	.
Solenidae												
Ensis directus	.	.	.	.	.	3	.	.	.	8	.	4
Tellinidae												
Tellina agilis	.	.	.	.	.	.	.	.	.	70	36	72
Macoma tenta	.	.	.	1	.	.	10	18	32	.	.	2
Veneridae												
Pitar morrhuana	1	5	4	10	5	10	107	101	86	1	2	.

Table 3-28 continued.

SPECIES	MQR CTR 1	MQR CTR 2	MQR CTR 3	FVP CTR 1	FVP CTR 4	FVP CTR 3	REFERENCE 1	REFERENCE 2	REFERENCE 3	STNH-N CTR 2	STNH-N CTR 3	STNH-N CTR 4
Paraonidae												
<u>Aricidea jeffreysii</u>	.	.	.	.	.	.	.	.	.	11	4	18
<u>Paraonis gracilis</u>	.	2	.	.	.	.	100	111	62	.	.	.
Pectinariidae												
<u>Pectinaria gouldii</u>	.	.	.	.	.	.	.	.	1	.	.	.
Pilargidae												
<u>Sigambra tentaculata</u>	.	.	.	3	.	.	19	26	31	12	13	20
<u>Ancistrosyllis groenlandica</u>	.	.	.	.	.	.	.	.	.	19	14	40
Phyllodocidae												
<u>Eulalia bilineata</u>	.	.	.	.	.	.	.	.	.	24	.	.
<u>Phyllodoce arenae</u>	.	.	.	.	.	5	.	.	.	.	.	.
Polynoidae												
<u>Harmothoe extenuata</u>	.	.	.	.	.	.	.	.	.	3	.	.
Sabellaridae												
<u>Sabellaria vulgaris</u>	.	.	.	.	.	2	.	.	.	.	.	.
Sabellidae												
<u>Sabella microphthalma</u>	.	.	.	.	.	.	.	.	1	.	.	.
Sigalionidae												
<u>Pholoe minuta</u>	.	.	.	.	.	.	.	1	.	.	.	4
Spionidae												
<u>Nerinides tridentata</u>	.	.	.	14	24	1	.	8	2	.	.	.
<u>Polydora ligni</u>	.	1	.	.	.	.	.	.	.	.	.	.
<u>Polydora socialis</u>	.	.	.	.	.	27	.	.	.	4029	3446	2264
<u>Prionospio steenstrupi</u>	.	.	.	1	.	1	.	.	.	4	4	2
<u>Spiophanes bombyx</u>	.	.	.	.	2	1	.	.	.	265	167	380
<u>Streblospio benedicti</u>	.	.	.	3	4	.	.	.	1	.	4	.

Table 3-28 continued.

SPECIES	MQR CTR 1	MQR CTR 2	MQR CTR 3	FVP CTR 1	FVP CTR 4	FVP CTR 3	REFERENCE 1	REFERENCE 2	REFERENCE 3	STNH-N CTR 2	STNH-N CTR 3	STNH-N CTR 4
Gastropoda												
Opisthobranchia												
Acteocina canaliculata	.	.	.	.	.	2	1	1	.	.	.	.
Acteon punctostriatus	.	.	.	.	1	1	.	.	.	.	.	.
Nassariidae												
Nassarius trivittatus	.	.	1	8	1	4	25	13	7	12	5	12
Pyramidellidae												
Turbonilla interrupta	.	.	.	.	.	.	.	3	2	5	.	6
Odostomia A	.	.	.	.	.	.	3	.	2	.	.	.
ARTHROPODA												
Crustacea												
Cephalocarida												
Hutchinsoniella macracantha	.	.	.	.	.	.	7	.	2	.	.	.
Amphipoda												
Gammaridea												
Ampeliscidae												
Ampelisca spp.	1	2	1	6	7	19	5	2	3	15	8	10
Corophiidae												
Unciola irrorata	.	.	.	.	.	1	2	.	.	23	13	30
Photidae												
Leptocheirus pinguis	.	.	.	.	.	.	.	.	.	34	4	8
Cumacea												
Diastylidae												
Oxyurostylis smithi	1	.	.	.	.	.	.	.	.	.	.	.

Table 3-28 continued.

SPECIES	MQR CTR 1	MQR CTR 2	MQR CTR 3	FVP CTR 1	FVP CTR 4	FVP CTR 3	REFERENCE 1	REFERENCE 2	REFERENCE 3	STNH-N CTR 2	STNH-N CTR 3	STNH-N CTR 4
Anomura												
Thalassinidea												
<u>Callianassa</u> <u>atlantica</u>	.	.	.	.	.	.	.	.	.	1	5	2
<u>Upogebia</u> <u>affinis</u>	.	.	.	.	.	.	.	.	.	.	5	2
Paguridae												
<u>Pagurus</u> <u>longicarpus</u>	.	.	1	.	.	2	.	.	.	6	5	.
Pinnotheridae												
<u>Pinnixa</u> sp.	.	.	.	2	.	.	.	.	.	.	.	.
Hemichordata												
<u>Saccoglossus</u> <u>kowalewskii</u>	.	.	.	.	.	.	6	8	1	.	.	.
Total number of species	15	13	12	21	20	29	26	27	26	38	30	32
Total number individuals	64	89	147	634	623	205	2429	2473	1260	4929	4440	3436
Polychaeta	48	68	122	485	554	130	320	338	231	4741	4343	3278
Mollusca	7	11	10	33	19	33	1988	1976	927	97	43	90
Crustacea *	2	2	2	8	7	22	7	2	3	79	40	52
Amphipoda	1	2	1	6	7	20	7	2	3	72	25	48

* Note that Amphipoda have been separated.

Table 3-29. Trace Metals In Body Tissues of Nephtys Collected At CLIS, August 1986

Station	As	Cd	Cr	Cu	Fe	Hg	Pb	Zn
	Concentration in ug/g dry weight							
Reference 1	26	0.92	0.22	17	650	0.15	3.8	170
Reference 2	23	1.1	0.30	21	740	0.085	3.8	190
Reference 3	19	0.58	0.20	18	600	0.25	3.2	170
Mean	23	0.87	0.24	19	663	0.16	3.6	177
±STD	3	0.22	0.04	2	58	0.07	0.3	9
STNH-N 1	0.61	1.20	0.62	25	340	0.14	1.4	240
STNH-N 2	0.75	0.94	0.55	22	340	0.35	1.2	200
STNH-N 3	0.76	1.10	0.53	26	660	0.12	1.6	240
Mean	0.71	1.08	0.57	24	447	0.20	1.4	227
±STD	0.07	0.11	0.04	2	151	0.10	0.2	19
FVP 1	18	0.86	0.57	45	350	0.13	8.8	190
FVP 2	18	0.85	0.90	51	450	0.15	8.7	180
FVP 3	19	0.96	2.40	48	680	0.22	7.9	160
Mean	19	0.91	1.49	47	515	0.18	8.4	175
±STD	0.5	0.05	0.80	3	138	0.04	0.4	12
MQR 1	15	1.0	0.69	32	590	0.13	9.2	190
MQR 2	20	1.0	1.1	31	750	0.17	9.7	190
MQR 3	18	0.85	1.2	26	820	0.023	9.7	180
Mean	18	0.95	1.0	30	720	0.11	9.5	187
±STD	2	0.07	0.2	3	96	0.06	0.2	5
CLIS-86 1	0.86	1.5	13	96	8600	0.094	26	150

Table 3-30. Trace Metals In Body Tissues of *Nephtys* Collected At CLIS, August 1986

Station	As	Cd	Cr	Cu	Fe	Hg	Pb	Zn
	Concentration in ug/g wet weight							
Reference 1	4.0	0.14	0.03	2.6	99	0.02	0.58	26
Reference 2	3.8	0.18	0.05	3.5	124	0.01	0.63	32
Reference 3	2.9	0.09	0.03	2.7	91	0.04	0.49	26
Mean	3.6	0.14	0.04	2.9	105	0.02	0.56	28
±STD	0.6	0.05	0.01	0.5	17	0.02	0.07	3
STNH-N 1	0.10	0.19	0.1	4.0	54	0.02	0.22	38
STNH-N 2	0.11	0.14	0.08	3.3	51	0.05	0.18	30
STNH-N 3	0.12	0.17	0.08	4.0	101	0.02	0.24	37
Mean	0.11	0.17	0.09	3.8	67	0.03	0.21	35
±STD	0.01	0.03	0.01	0.4	28	0.02	0.03	4
FVP 1	2.6	0.12	0.08	6.4	50	0.02	1.2	27
FVP 2	2.9	0.14	0.14	8.2	72	0.02	1.4	29
FVP 3	2.8	0.14	0.35	7.0	99	0.03	1.2	23
Mean	2.8	0.13	0.19	7.2	74	0.02	1.3	26
±STD	0.2	0.01	0.14	0.9	25	0.01	0.1	3
MQR 1	2.6	0.18	0.12	5.6	103	0.02	1.6	33
MQR 2	3.6	0.18	0.2	5.6	135	0.02	1.7	34
MQR 3	1.6	0.14	0.19	4.2	115	<.008	1.6	29
Mean	2.6	0.17	0.17	5.1	118	---	1.6	32
±STD	1.0	0.02	0.04	0.8	16	---	0.1	3
CLIS-86 1	0.17	0.3	2.6	19	1690	0.02	5.1	30

--- = Not applicable.

Table 3-31. PCB'S In Body Tissues Of Nephtys Collected At CLIS, August 1986

STATION	Dry Weight	Wet Weight
	(Concentrations as ppb[1])	
Reference 1	<380	<58
Reference 2	<490	<82
Reference 3	<480	<73
STNH-N 1	<340	<54
STNH-N 2	<260	<39
STNH-N 3	<340	<52
FVP 1	<770	<109
FVP 2	<580	<93
FVP 3	<330	<48
MQR 1	<270	<47
MQR 2	<440	<79
MQR 3	<380	<61
CLIS-86 1	<290	<57

[1] - Detection limits as Aroclor 1254. No other PCB mixtures were detected.

Table 3-32. Results of Statistical Testing For Significant Differences In Chemical Concentrations In *Nephtys incisa* Collected At CLIS, July 1986

Variable	STNH-N	FVP	MQR
As	-	ns	ns
Cd	ns	ns	ns
Cr	+	+	+
Cu	+	+	+
Fe	ns	ns	ns
Hg	ns	ns	ns
Pb	-	+	+
Zn	+	ns	ns

\+ = concentrations significantly higher than Reference animals, $p \leq 0.05$, Kruskal-Wallis, one-way analysis of variance.
\- = concentrations significantly less than Reference animals, $p \leq 0.05$.
ns = no significant difference, $p > 0.05$.

Table 4-1. Summary Organism - Sediment Index Ranking CLIS Disposal Mounds, 1986

Area	Stations	N	XOSI	St. Dev.	Min.	Max.
CLIS-REF	Ambient	20	9.58	1.71	3	11
STNH-N	Mound	12	9.50	1.78	5	11
	Edge and Ambient	5	9.40	0.89	8	10
GHOST-1	Ambient	48	9.15	1.90	5	11
FVP	Mound	34	9.00	2.28	4	11
	Edge and Ambient	26	9.23	2.45	3	11
GHOST-2	Ambient	48	8.96	1.89	6	11
CAP-2	Mound	9	8.56	2.35	6	11
	Edge and Ambient	8	9.50	1.69	7	11
STNH-S	Mound*	14	7.79	2.33	4	11
	Edge and Ambient*	3	7.00	2.00	5	9
CAP-1	Mound*	16	7.75	2.08	5	11
	Edge and Ambient	1	11.00	---	---	---
NORWALK	Mound	9	7.56	2.88	3	10
	Edge and Ambient	8	8.63	2.39	4	11
NH74	Mound	16	7.38	3.50	4	11
	Edge and Ambient	1	11.00	---	---	---
CLIS86	Mound*	14	7.29	2.64	4	11
	Edge and Ambient	3	9.33	2.08	7	11
NH83	Mound*	14	5.86	1.75	4	10
	Edge and Ambient	2	9.50	2.12	8	11
MQR	Mound*	45	5.58	2.59	-3	10
	Edge and Ambient	3	7.67	2.31	3	9

* = Significantly different from the CLIS Reference Station (Kruskal-Wallis Test $P \leq 0.05$).

--- = Not Applicable.

Table 4-2. Comparison of Sediment Chemical Concentrations from the Central Long Island Disposal Site with Other Reported Values in Long Island Sound.

	Central Long Island Disposal Site			Benninger[4]	Munns[5]	Munns[5]	Greig[6]
	CLIS Mounds[1]	Reference[2]	FVP[3]	CLIS-REF	CLIS-REF	FVP	CLIS-REF
Pb	21-373	70-81	68-163	21-52	45-52	28-104	44-50
Zn	13-744	101-122	104-272	106-190	134-160	88-385	118-140
Cu	<13-514	33-44	62-529	31-96	46-62	92-756	64-86
Cr	<18-182	20-41	46-266	---	40-58	53-370	127*
Cd	<3-5	<3	<3-4	---	0.1-0.2	0.5-8.1	<1.3*
Ni	<28-71	<28	<28-36	---	21-24	14-35	13-17
Hg	0.12-4.15	0.08-0.14	0.18-0.57	---	---	---	0.2*
Tot.C[7]	0.19-3.85	1.94-2.23	1.89-3.19	---	2.03-2.38	1.09-3.53	---
PCBs[8]	0.04-0.86	0.06	0.82	---	0.03	0.07	---

1 From all disposal mounds samples (0-10cm) taken July 1986, excluding the FVP mound.
2 From the Reference station samples (0-10cm) taken July 1986.
3 From the FVP mound samples (0-10cm) taken July 1986.
4 Benninger et al. (1979). (0-10cm samples).
5 Munns *et al.* (In press). Note that metal and PCB concentration ranges are taken from 1985 data; % Tot.C values are taken from 1983-1984 data. All samples are from (0-12cm).
6 Grieg et al. (1977). Ranges from three stations in the vicinity of CLIS-REF, (0-4cm).
7 % Total Carbon.
8 All concentrations reported in ppm.
--- Parameter not tested for at these stations.
* Only one value reported.

Table 4-3. Comparison Of REMOTS, And Benthic Summary Parameters

AREA	Average OSI Value	Average Species Richness	Average Log-Abundance
CLIS Reference Station	9.55	35	3.31
STNH-N	9.50	42	3.63
FVP	9.00	37	2.68
MQR	5.58	20	2.00

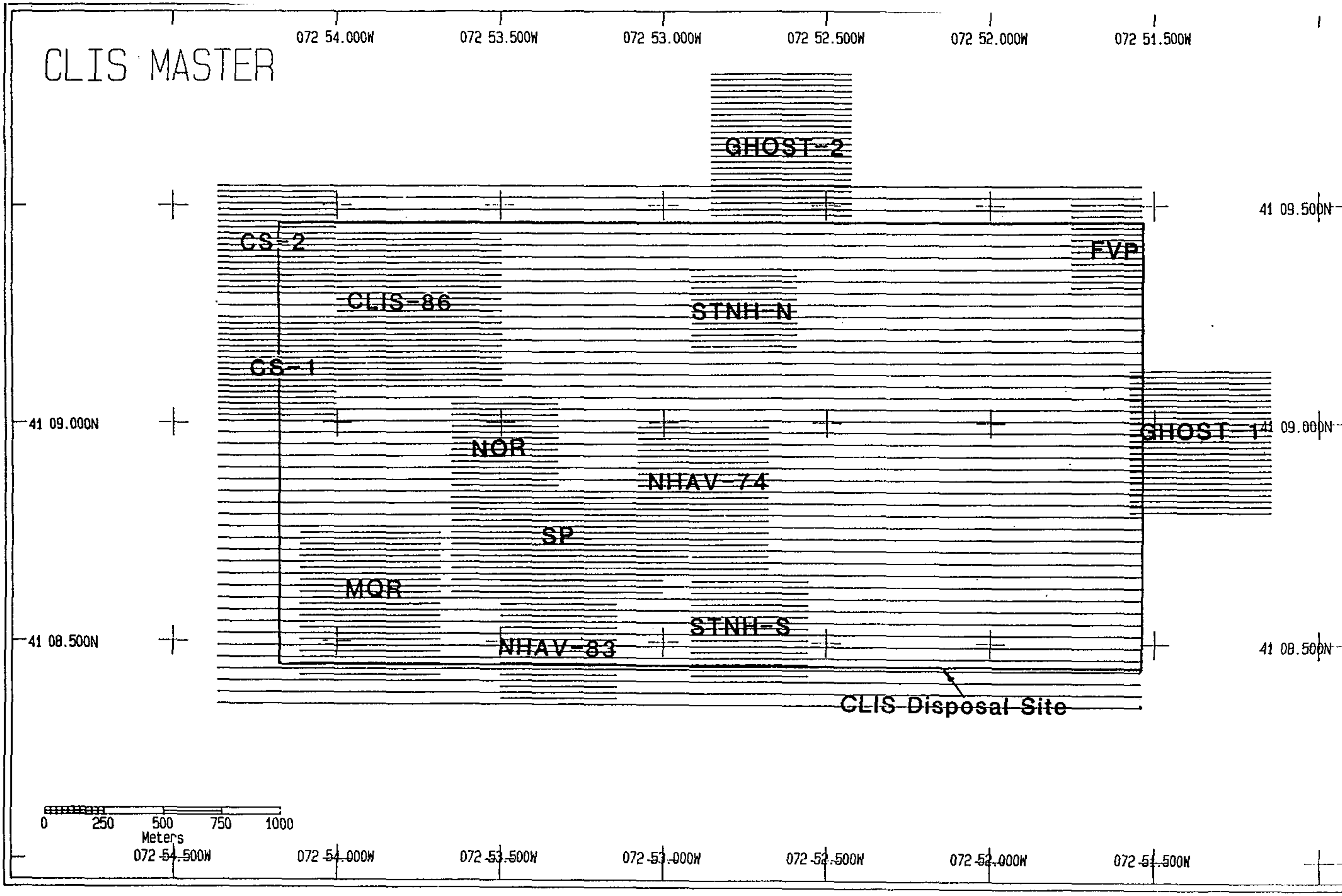


Figure 1-1. Survey lanes at the Central Long Island Sound (CLIS) disposal site. SP = Location of special projects buoy monitored by US coast Guard. See text for explanation of other abbreviations.

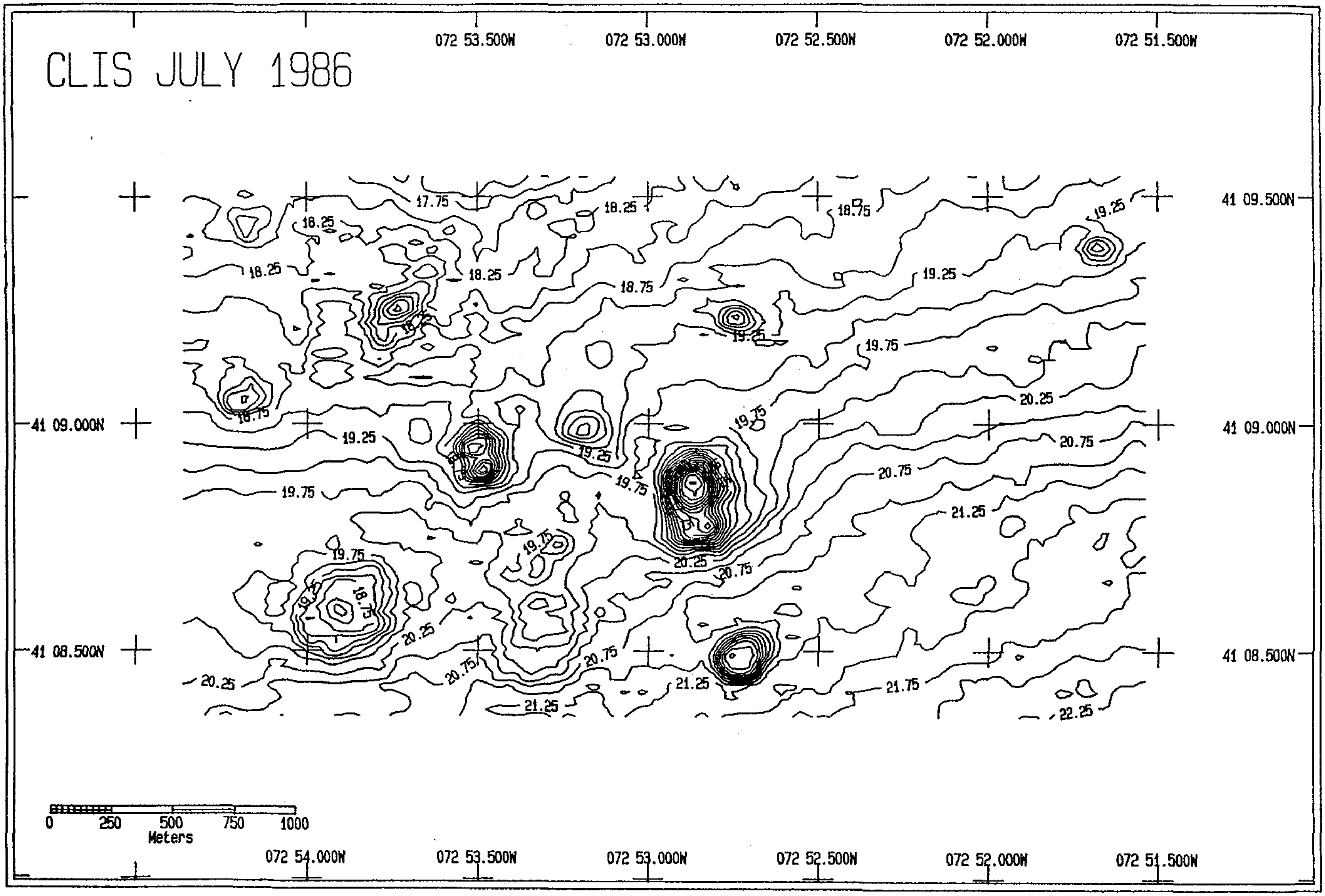


Figure 3-1. Bathymetric contour chart (m) of CLIS, July 1986.

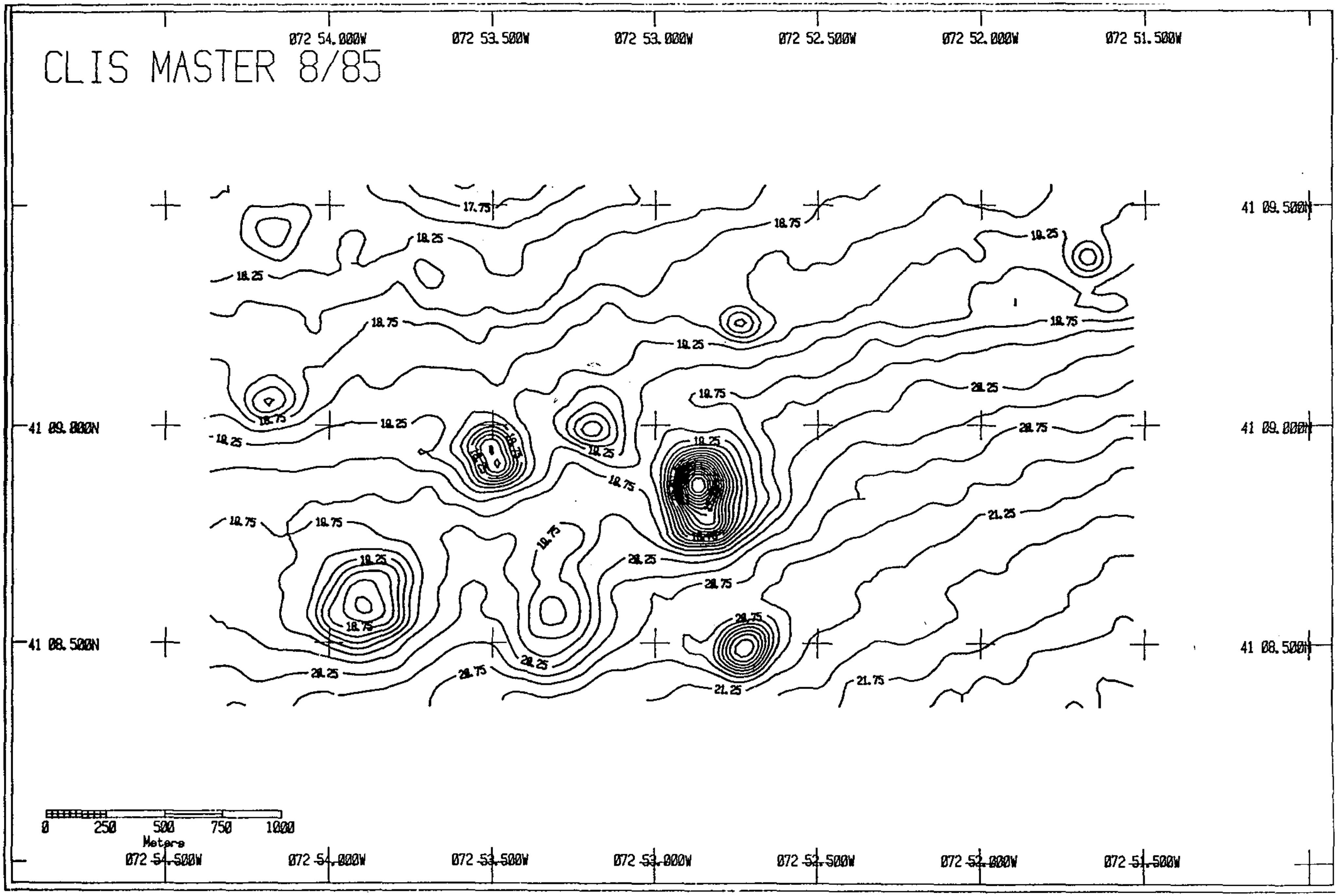


Figure 3-2. Bathymetric contour chart (m) of CLIS, July 1985.

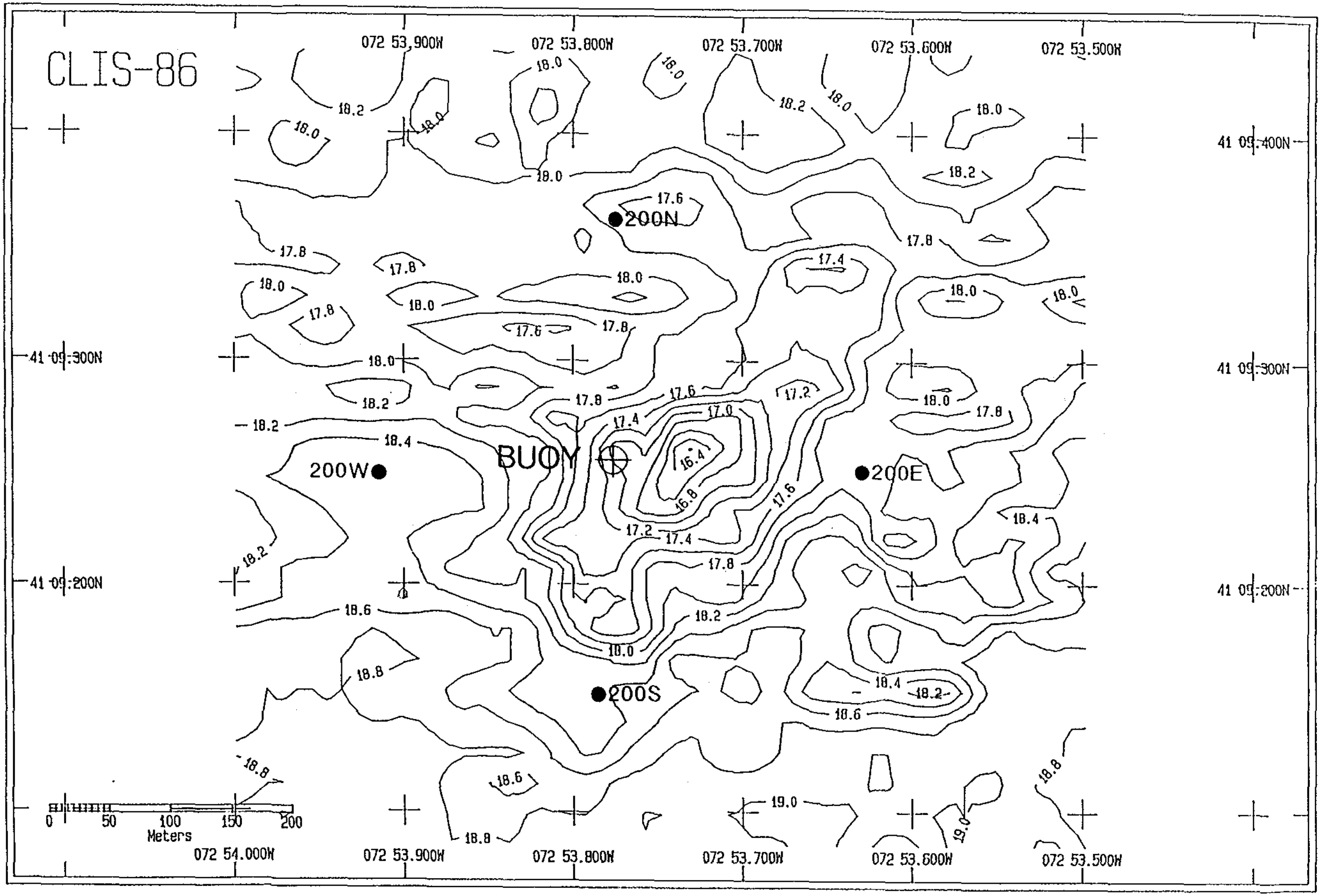


Figure 3-3. Bathymetric contour chart (m) of the new CLIS-86 disposal mound, July 1986. The locations of REMOTS® stations 200W, 200E, 200N and 200s are indicated.

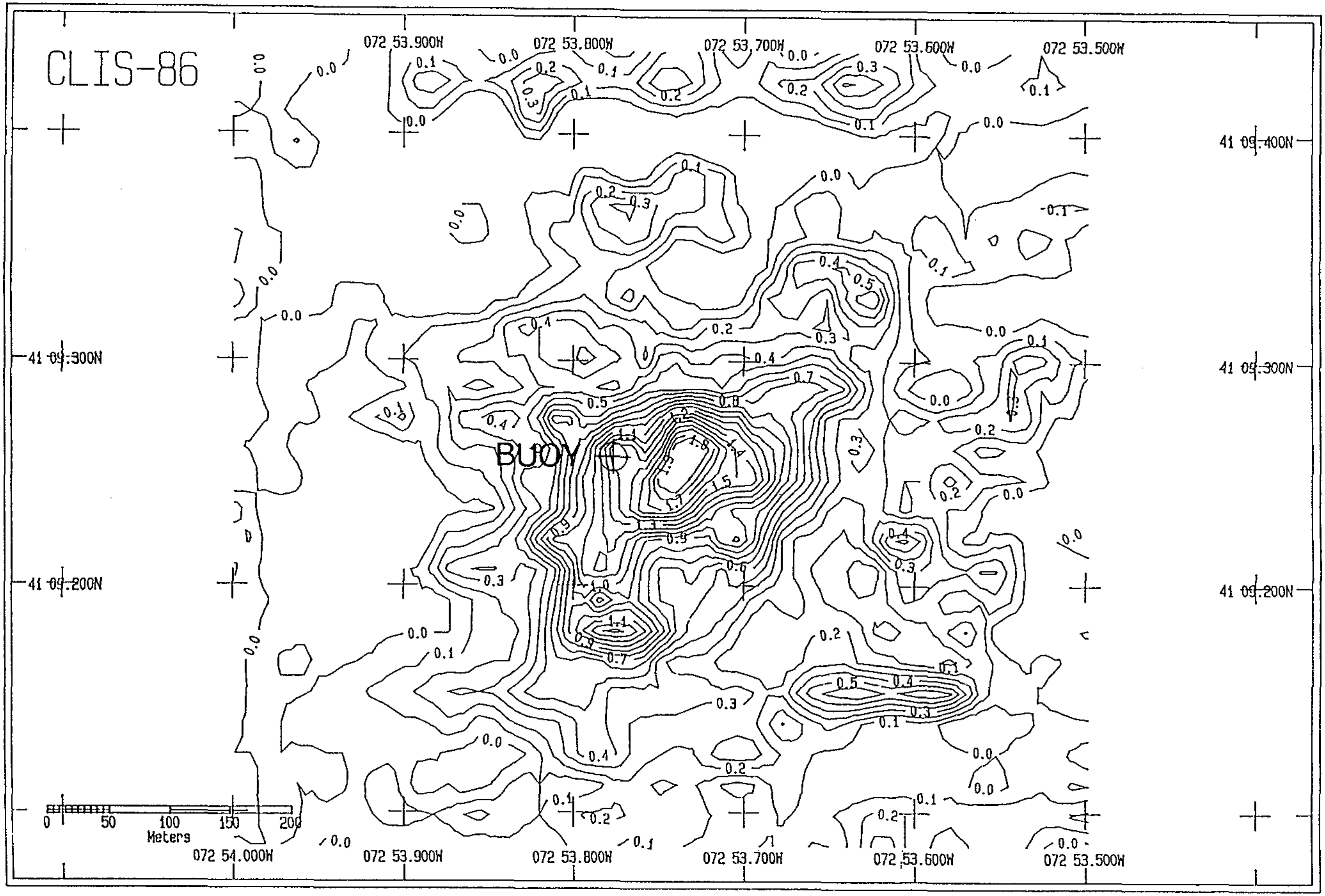


Figure 3-4. Depth difference contour chart (m) of the new CLIS-86 disposal mound, based on comparison of the August 1985 and July 1986 precision bathymetric surveys.

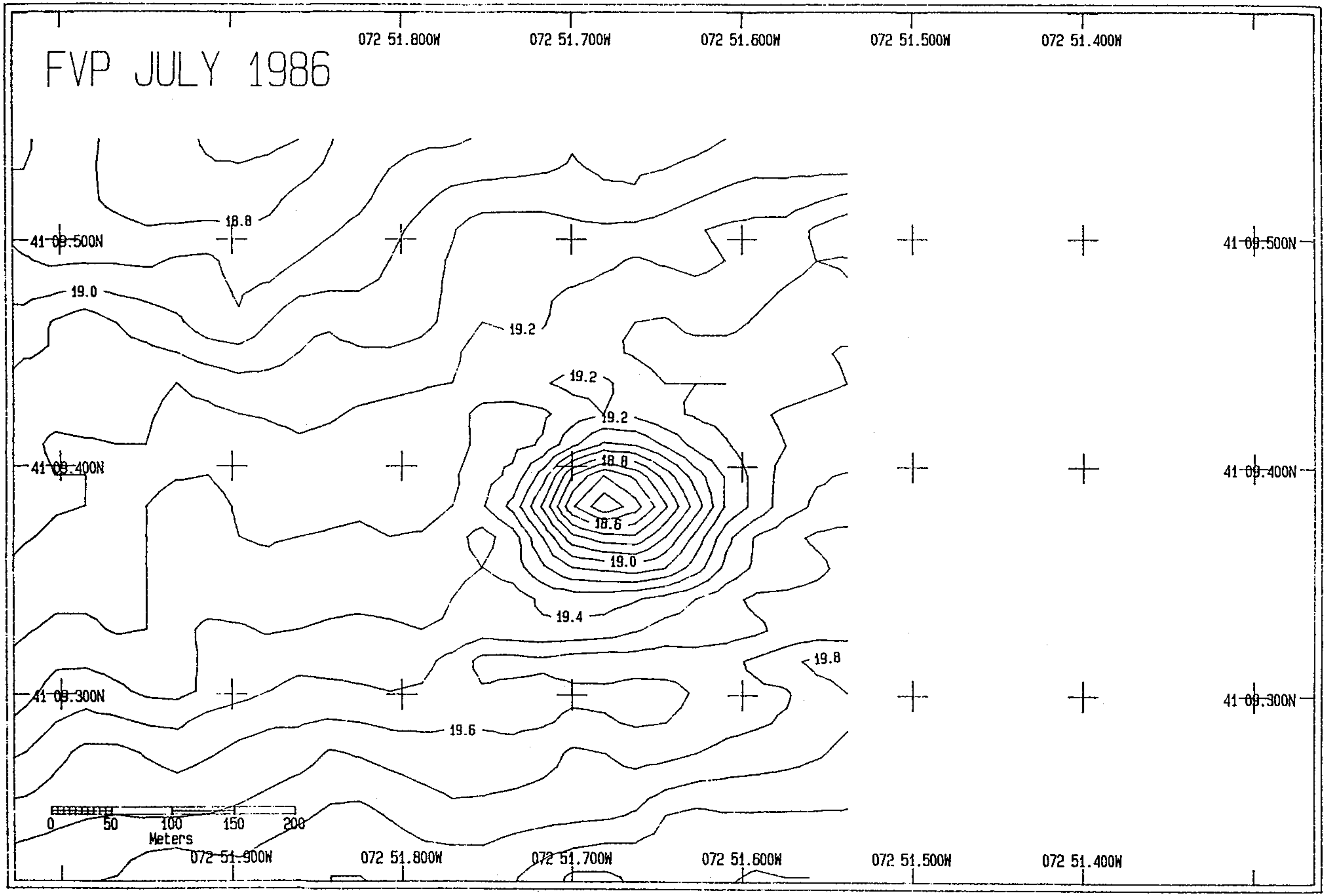


Figure 3-5. Bathymetric contour chart (m) of FVP, July 1986.

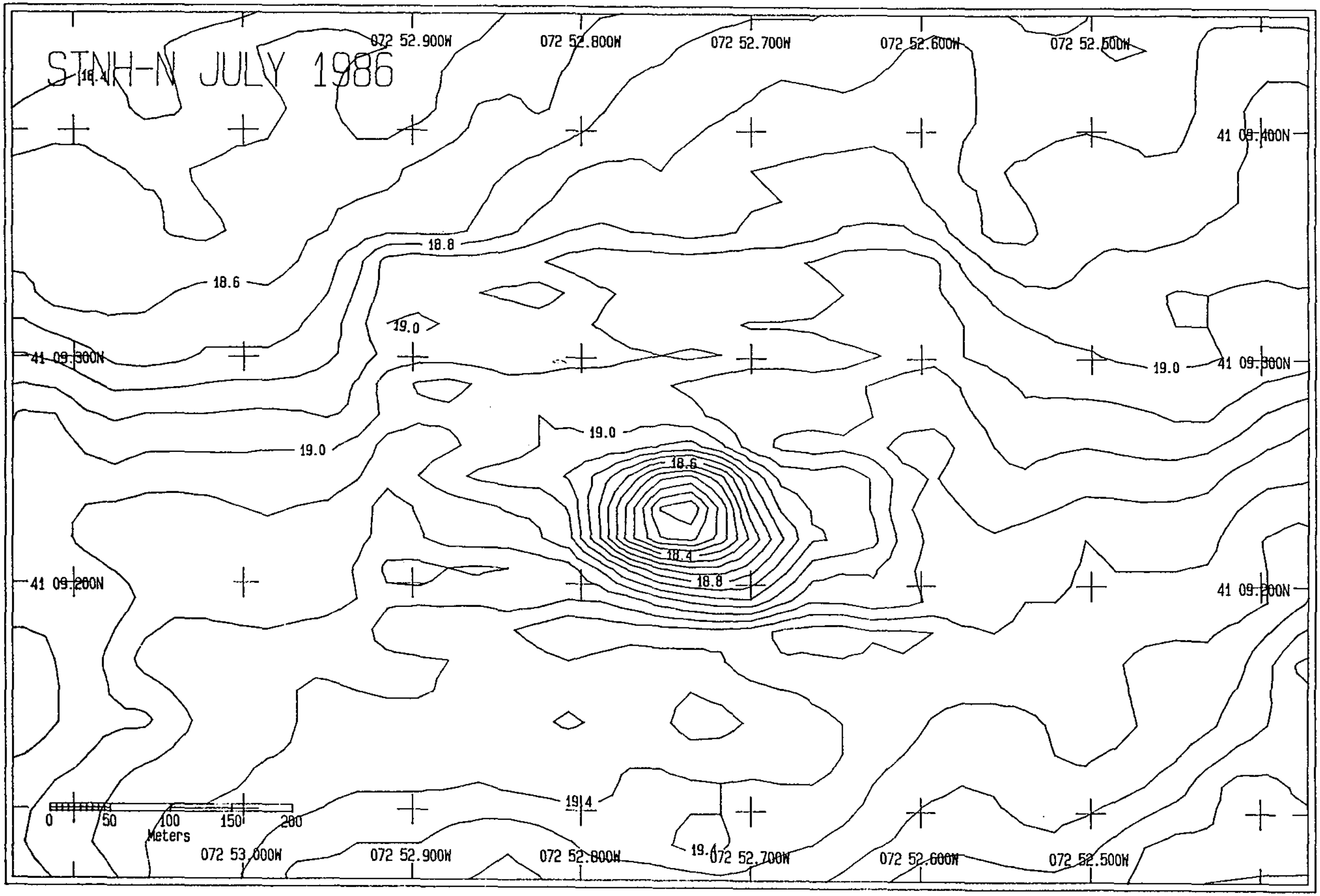


Figure 3-6. Bathymetric contour chart (m) of STNH-N, July 1986.

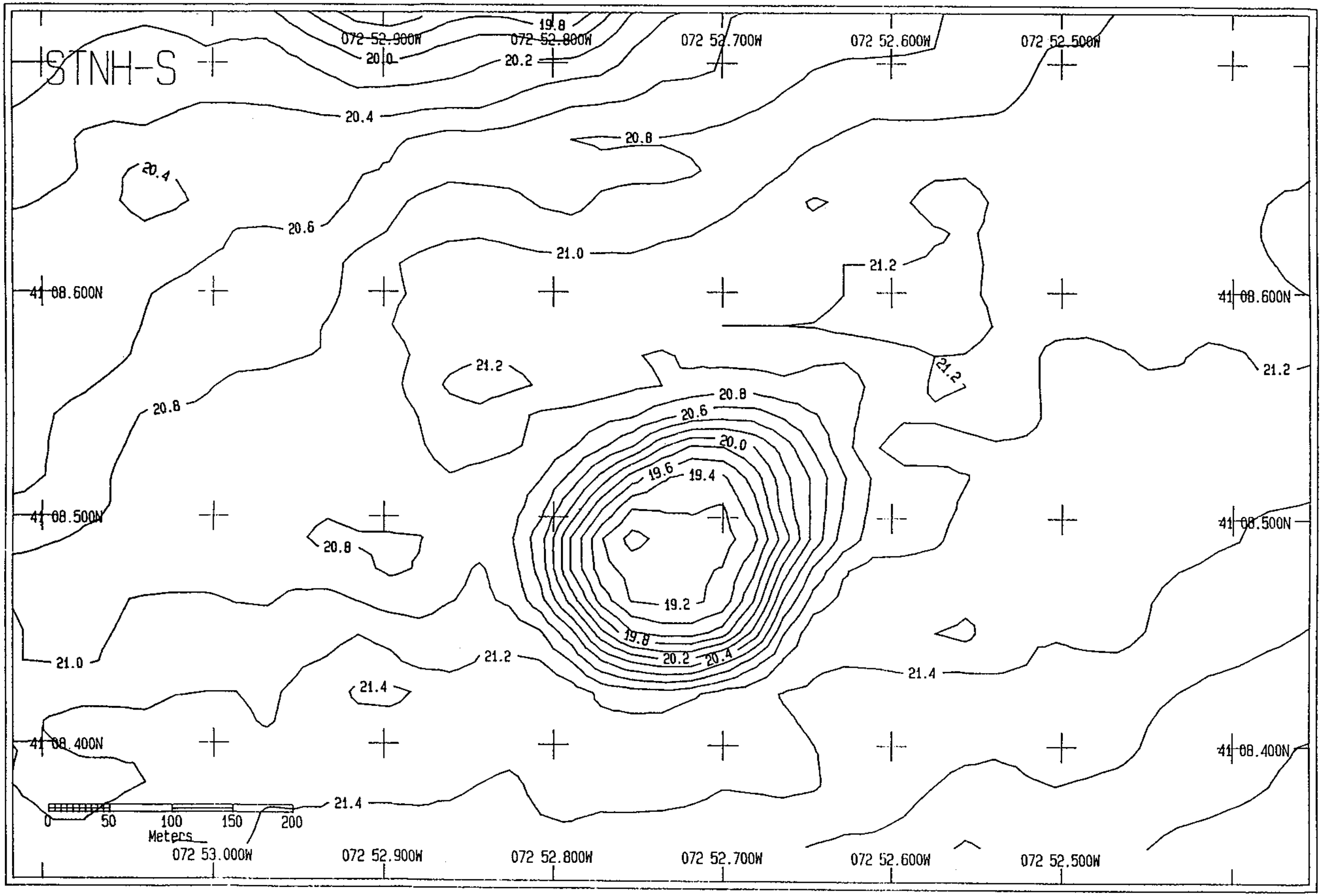


Figure 3-7. Bathymetric contour chart (m) of STNH-S, July 1986.

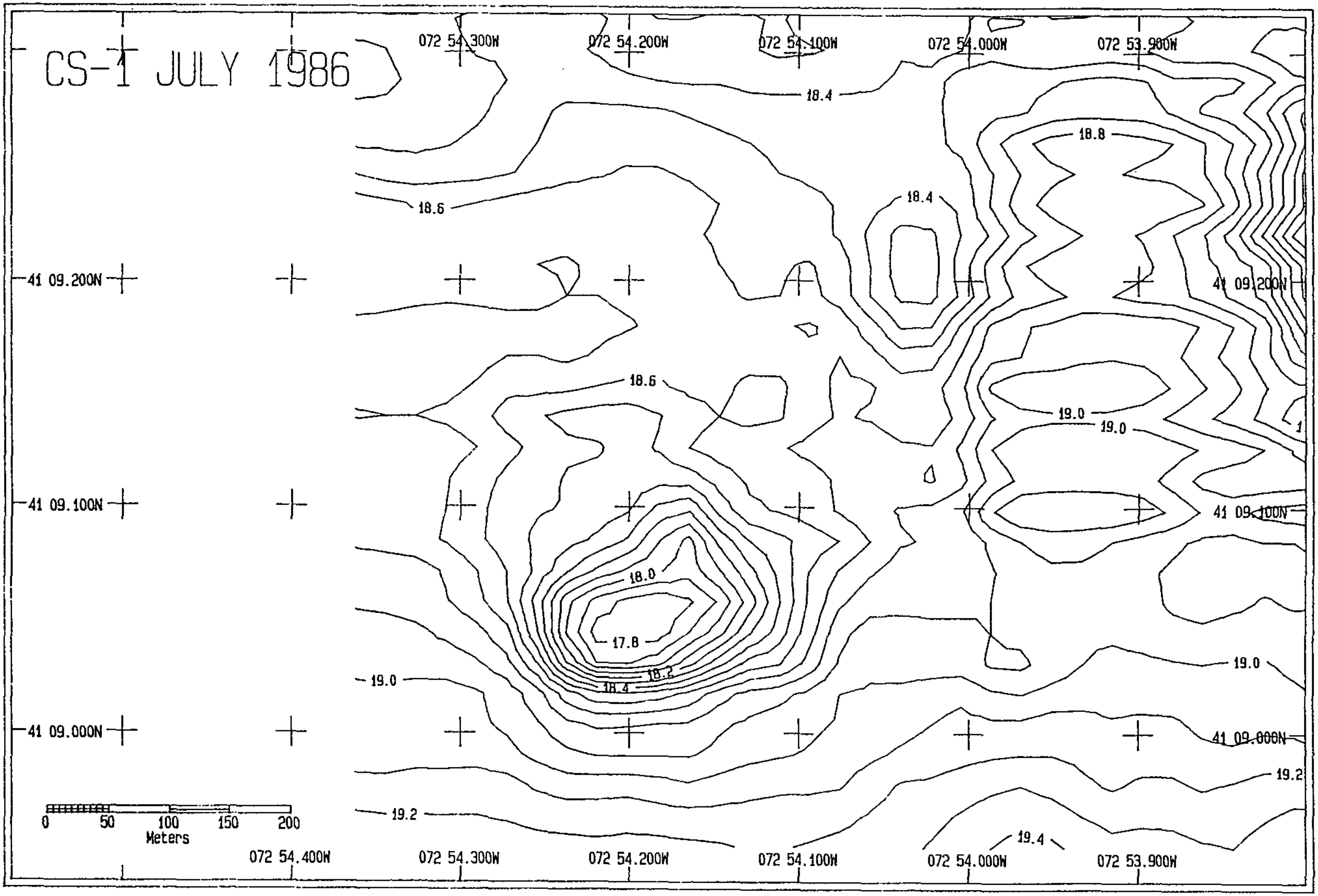


Figure 3-8. Bathymetric contour chart (m) of Cap Site 1, July 1986.

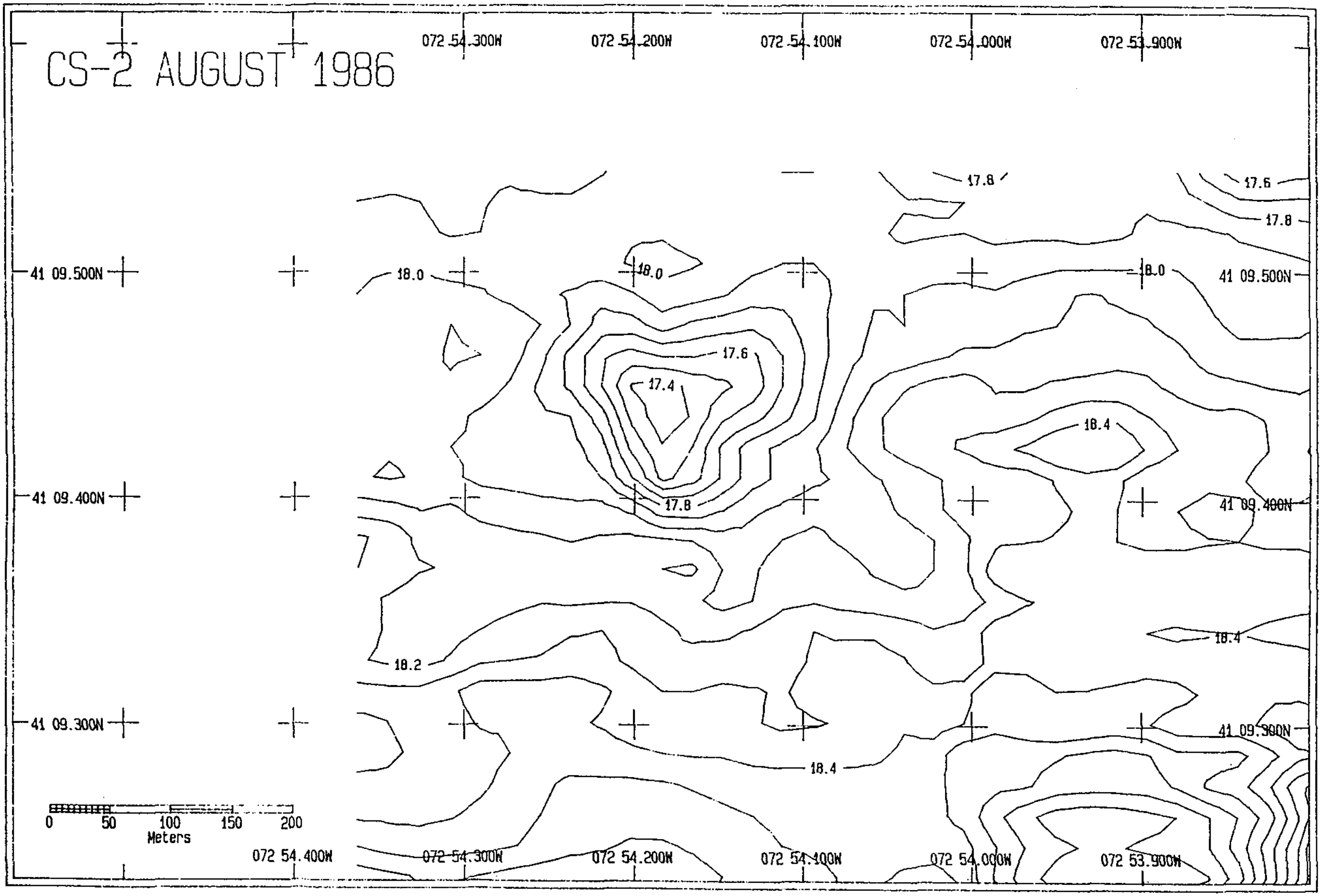


Figure 3-9. Bathymetric contour chart (m) of Cap Site 2, July 1986.

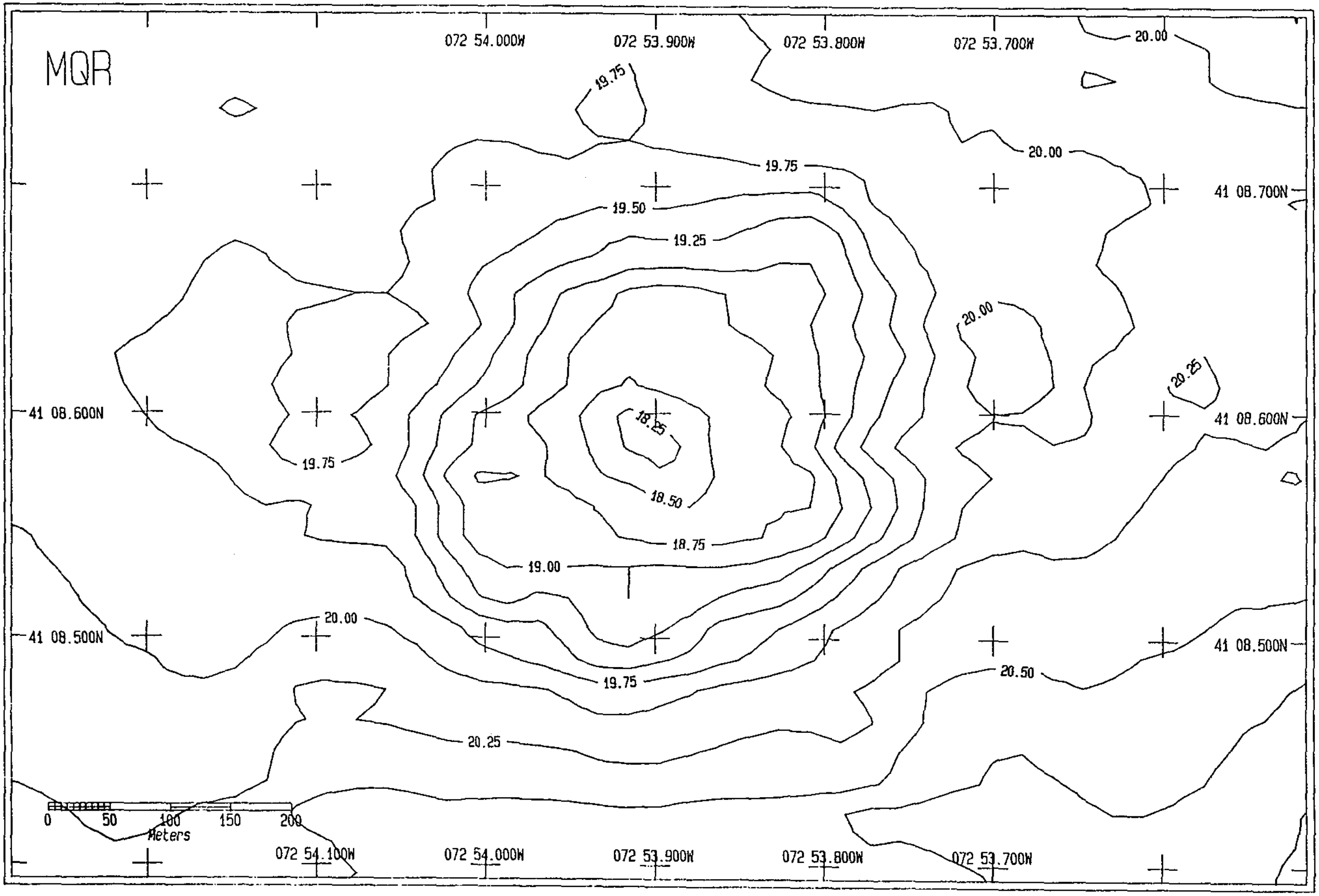


Figure 3-10. Bathymetric contour chart (m) of MQR, July 1986.

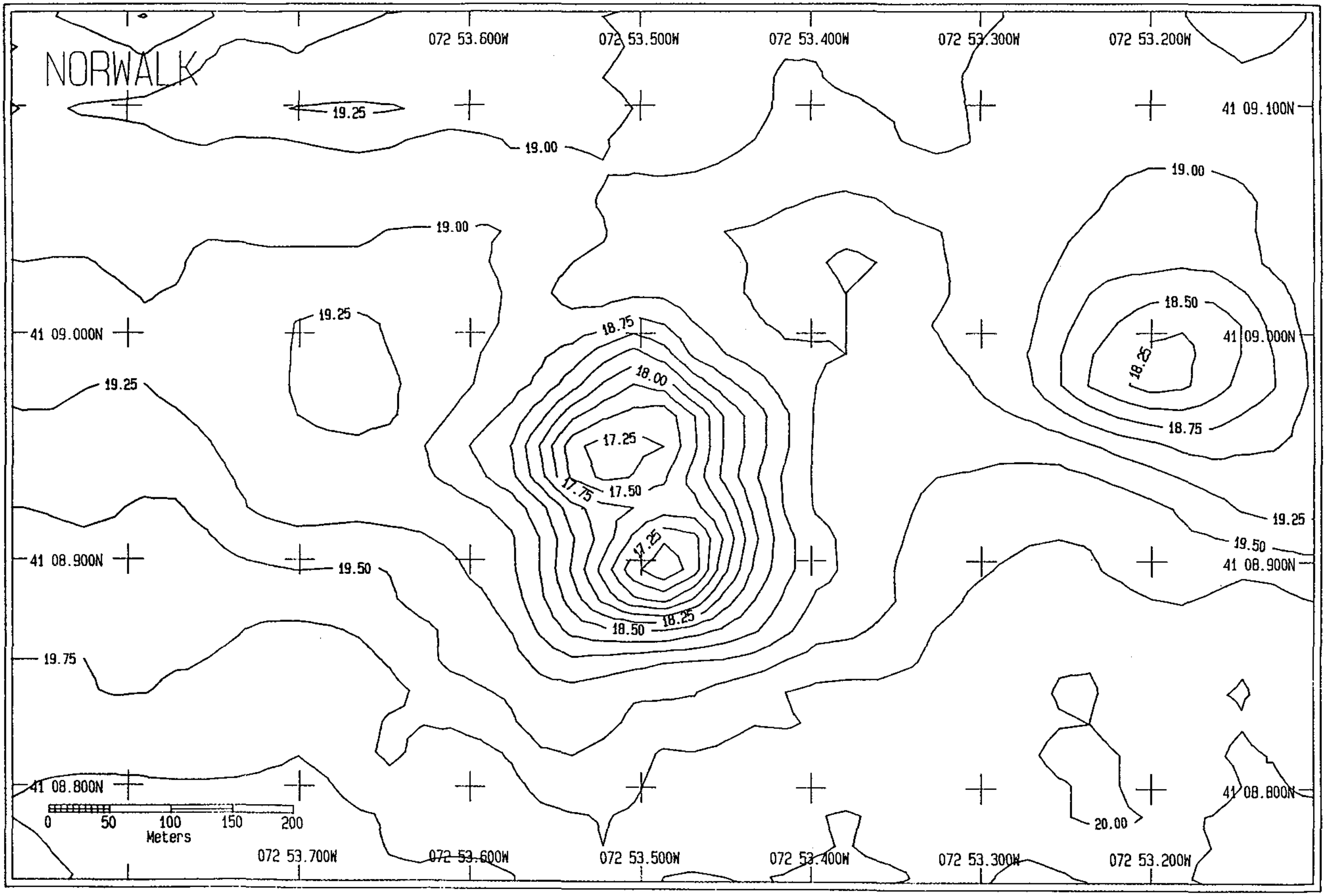


Figure 3-11. Bathymetric contour chart (m) of NORWALK, July 1986.

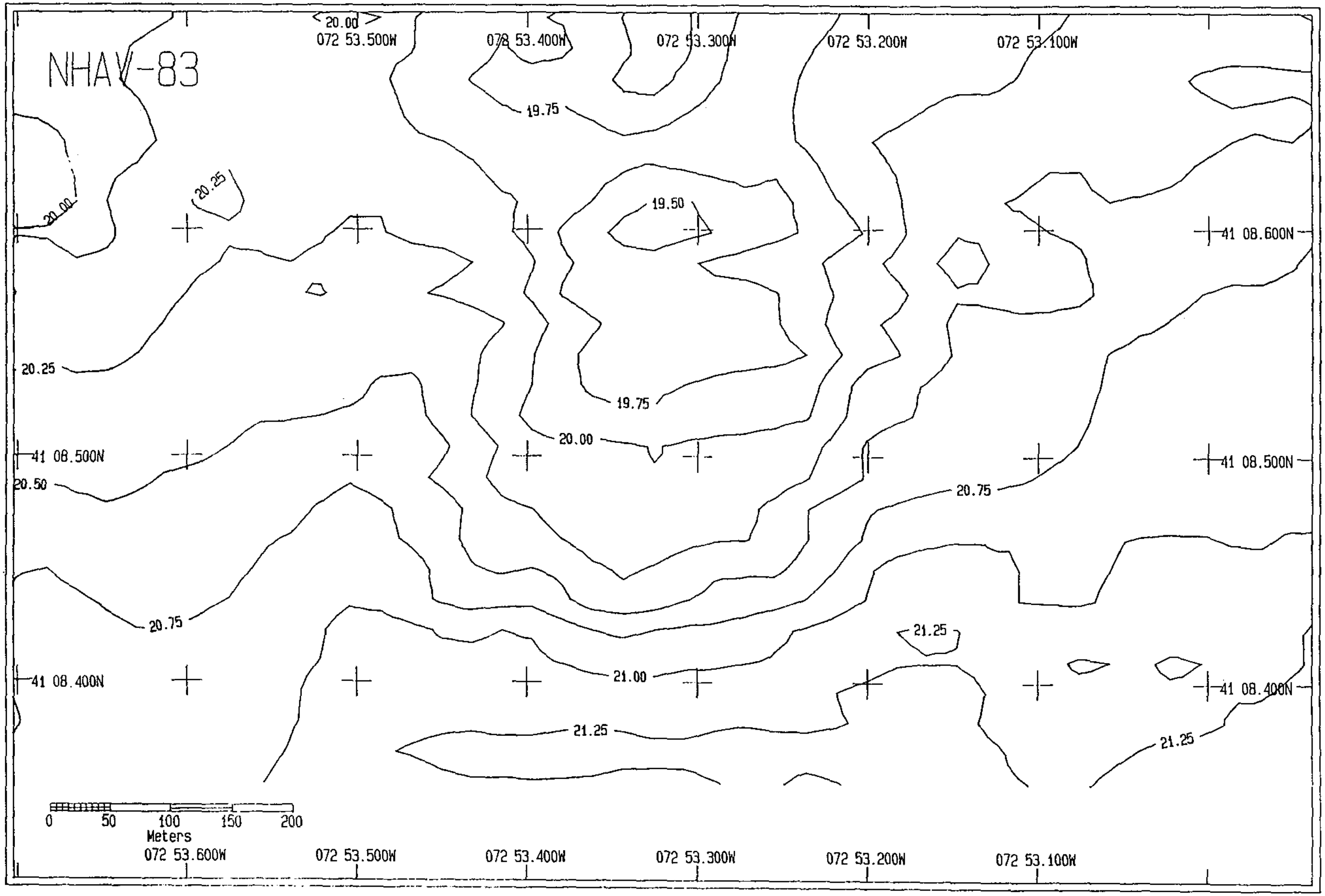


Figure 3-12. Bathymetric contour chart (m) of NHAV-83, July 1986.

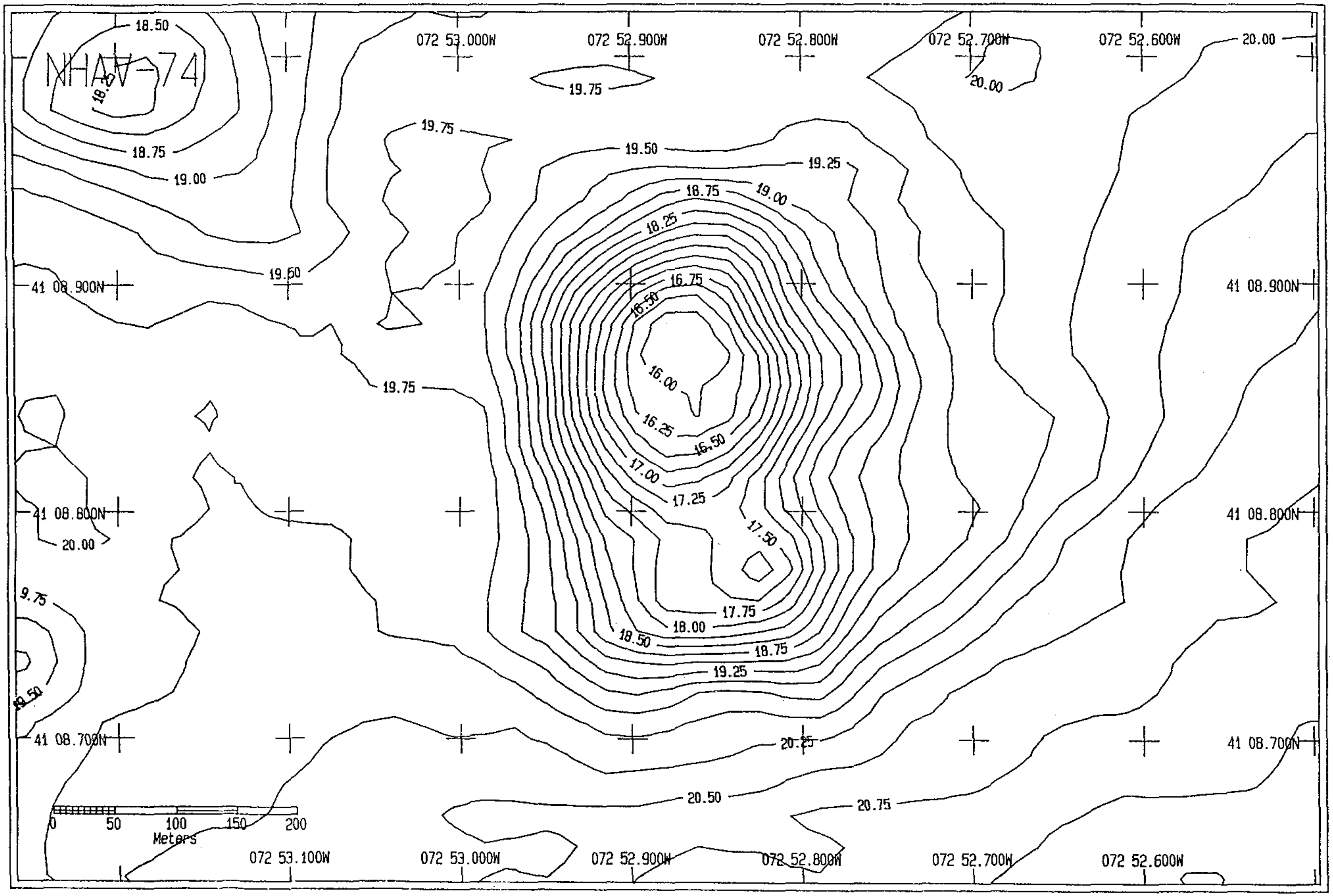


Figure 3-13. Bathymetric contour chart (m) of NHAV-74, July 1986.

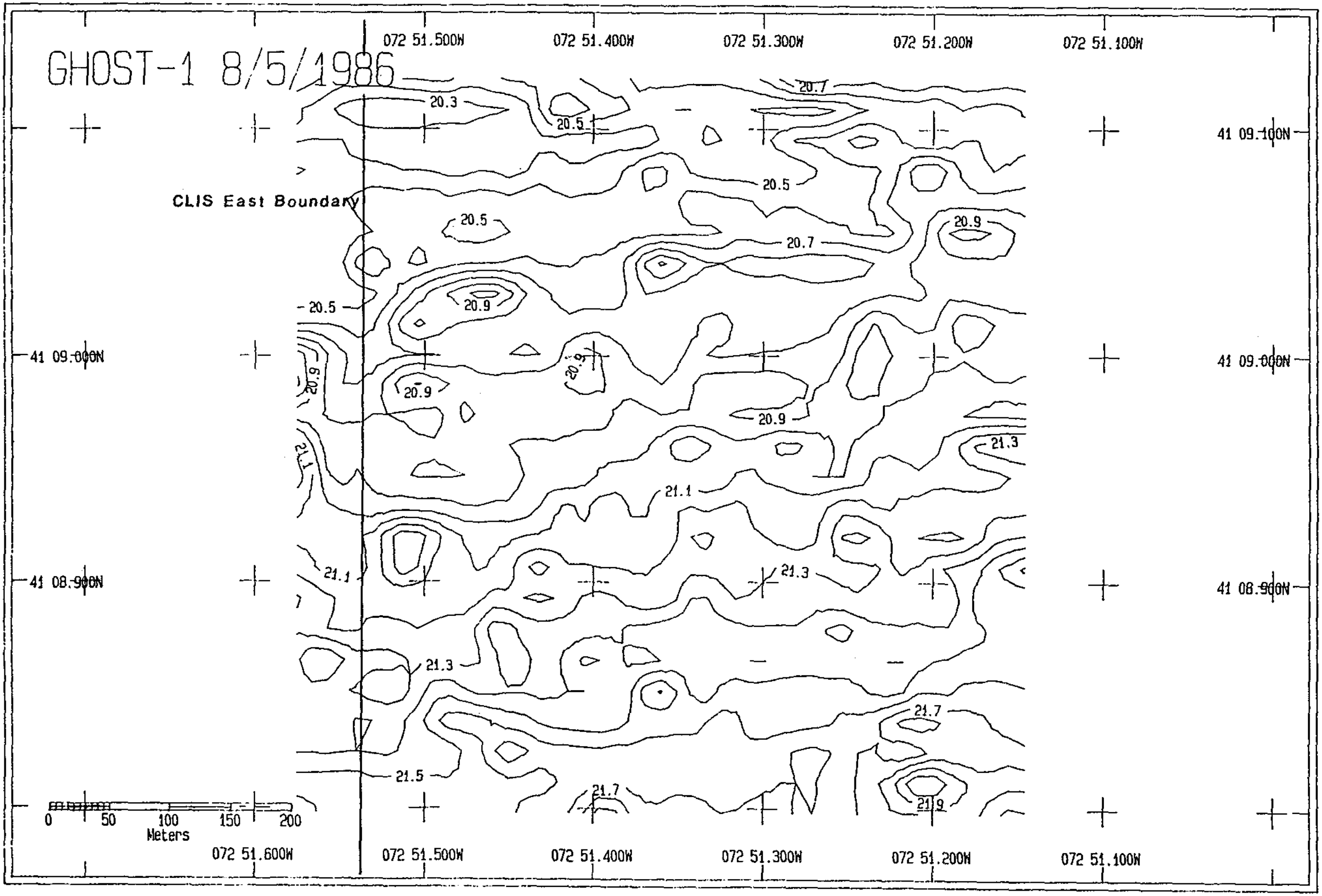


Figure 3-14. Bathymetric contour chart (m) of GHOST-1, August 1986.

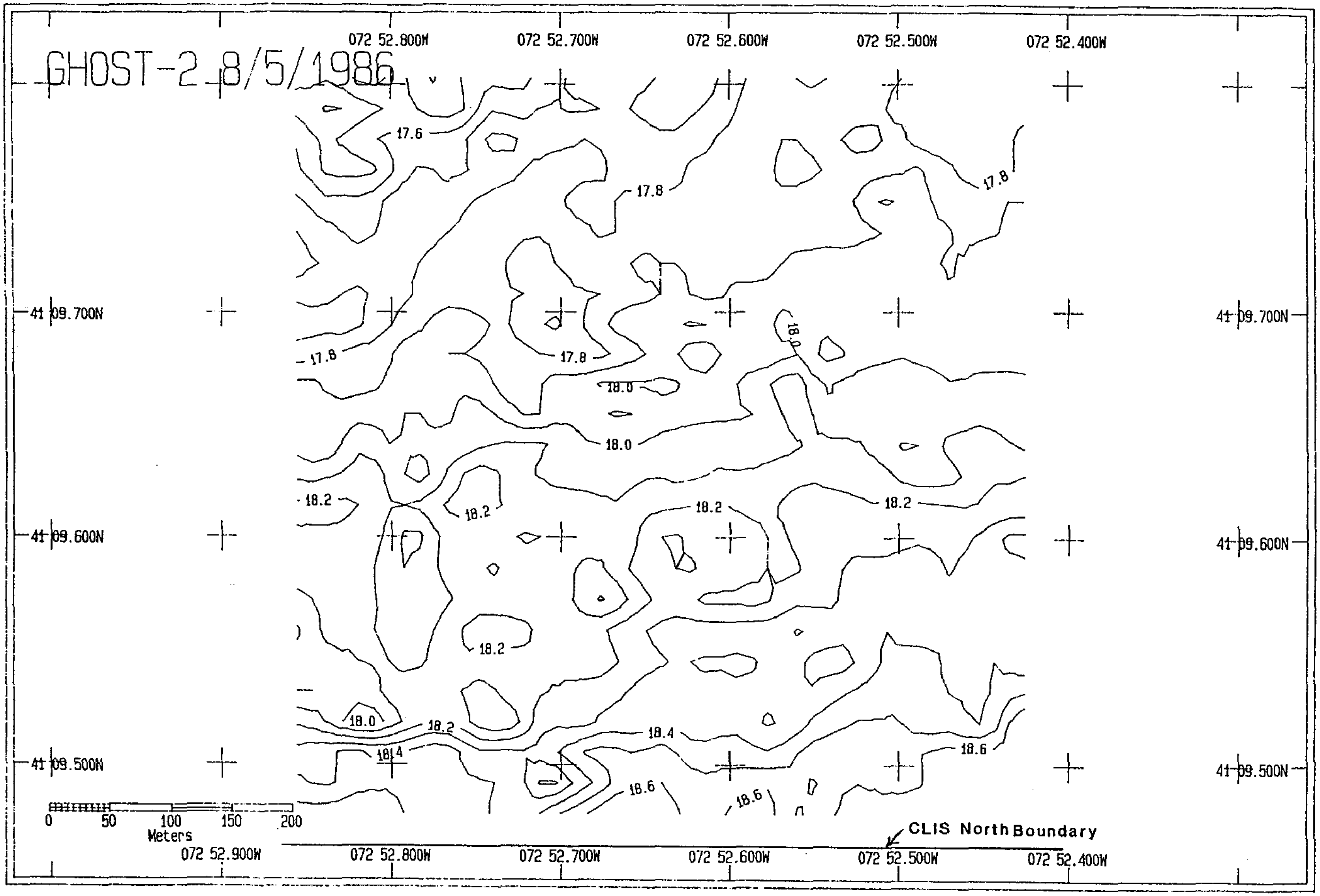


Figure 3-15. Bathymetric contour chart (m) of GHOST-2, August 1986.

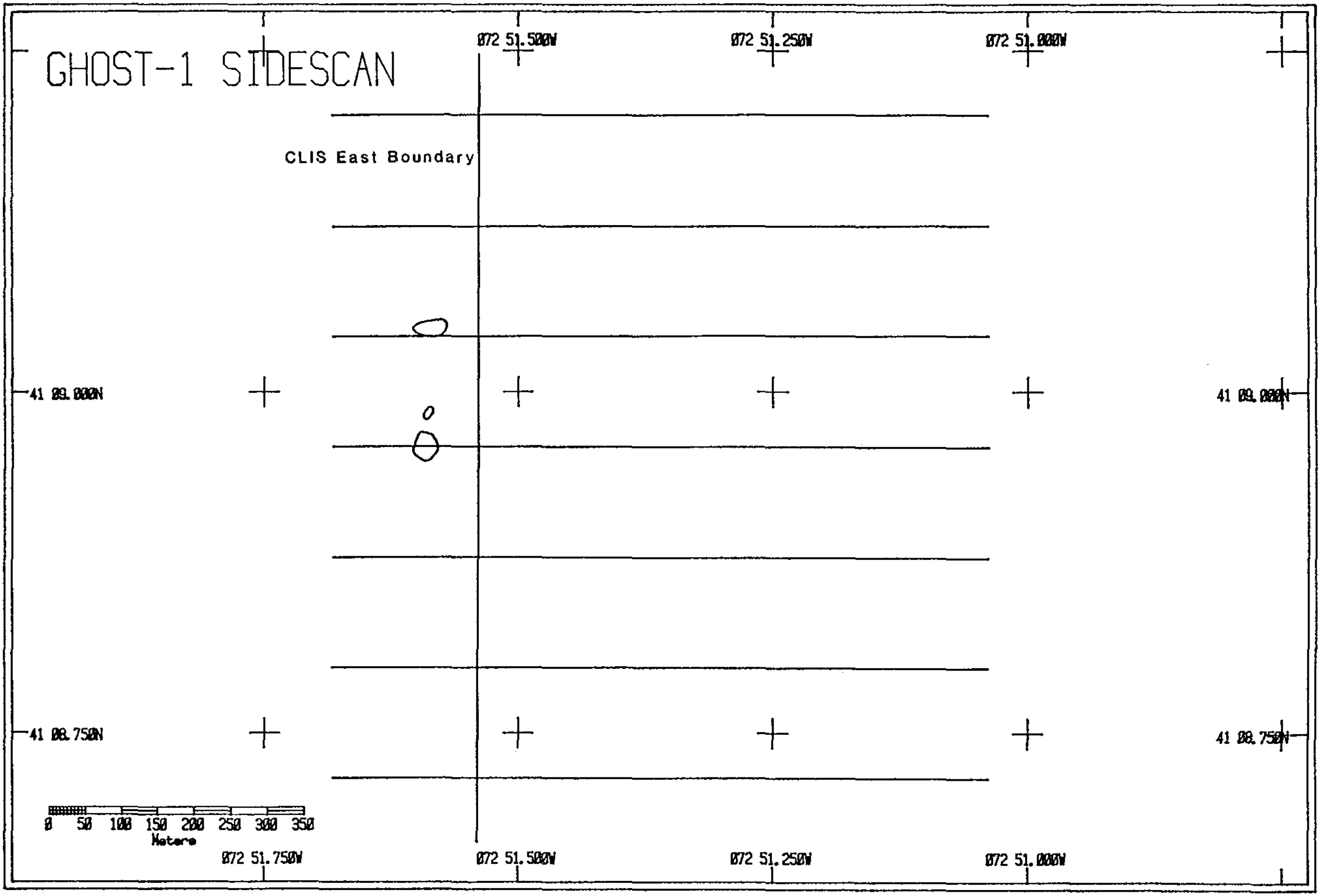


Figure 3-16. Results of GHOST-1 side scan survey, August 1986. Enclosed areas indicate high reflectance.

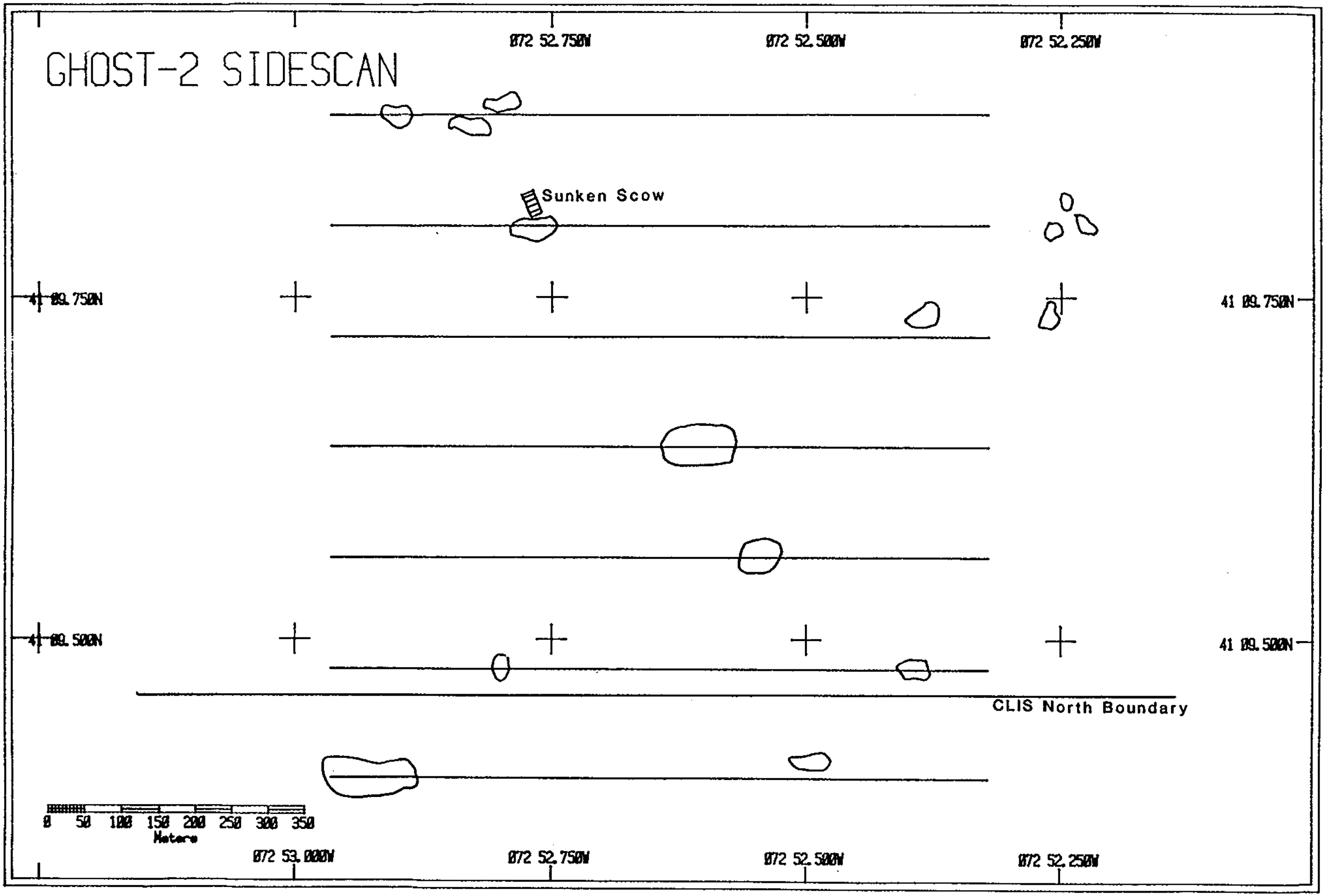


Figure 3-17. Results of the GHOST-2 side scan sonar survey, August 1986. Enclosed areas indicate high reflectance.

Figure 3-18. Benthic "process" map indicating the distribution and thickness (cm) of apparent dredged material at the FVP disposal mound in July 1986. Dashed lines delimit those stations considered to be located on the main dredged material mound or mound flanks ("mound stations") based on REMOTS® and bathymetric surveys conducted immediately after the FVP disposal operation (May 24, 1983). Stations outside this line are termed "edge and ambient." The solid line delimits the extent of apparent dredged material based on the results of the present survey. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

SHELL = Shell lag deposits

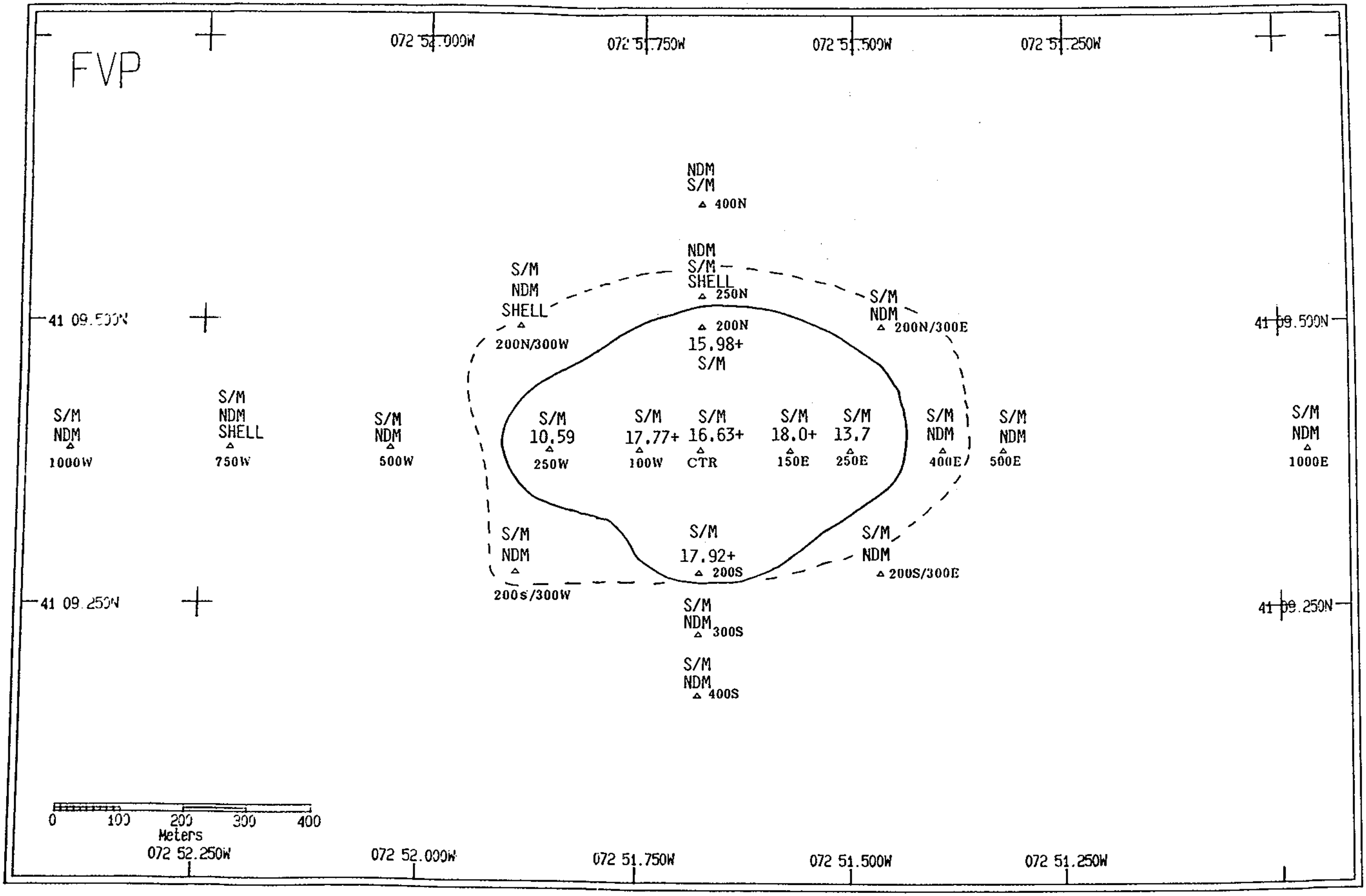

FVP
072 52.000W
072 51.750W
072 51.500W
072 51.250W
41 09.500N
41 09.250N
NDM
S/M
400N
NDM
S/M
SHELL
250N
S/M
NDM
SHELL
200N/300W
S/M
NDM
200N/300E
200N
15.98+
S/M
S/M
NDM
1000W
S/M
NDM
SHELL
750W
S/M
NDM
500W
S/M
10.59
250W
S/M
17.77+
100W
S/M
16.63+
CTR
S/M
18.0+
150E
S/M
13.7
250E
S/M
NDM
400E
S/M
NDM
500E
S/M
NDM
1000E
S/M
NDM
200S/300W
S/M
17.92+
200S
S/M
NDM
200S/300E
S/M
NDM
300S
S/M
NDM
400S
0
100
200
300
400
Meters
072 52.250W
072 52.000W
072 51.750W
072 51.500W
072 51.250W

Figure 3-18.

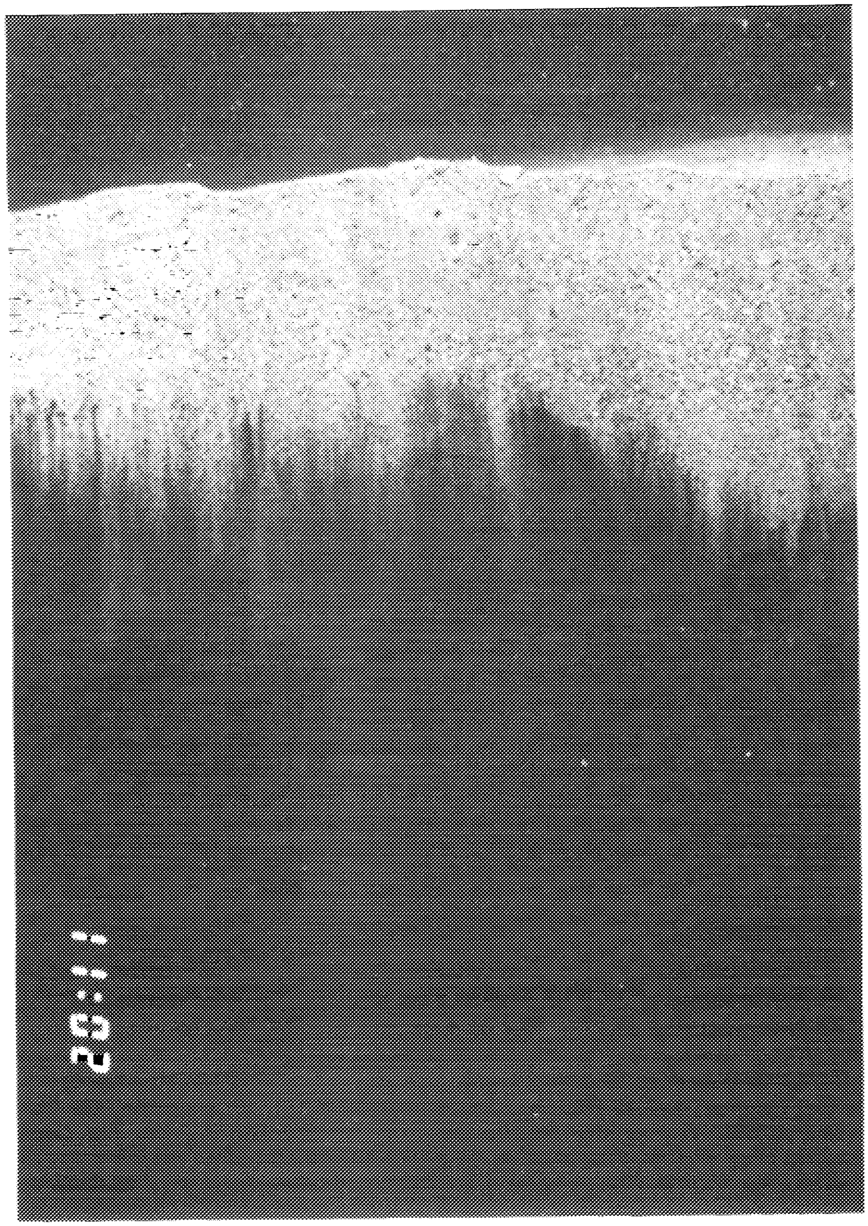


Figure 3-19. REMOTS® image from station Center at FVP showing a sand component in the near surface sediment. This sand component is interpreted to represent a lag deposit resulting from washing of fines from the apex of the disposal mound. Scale = 1X.

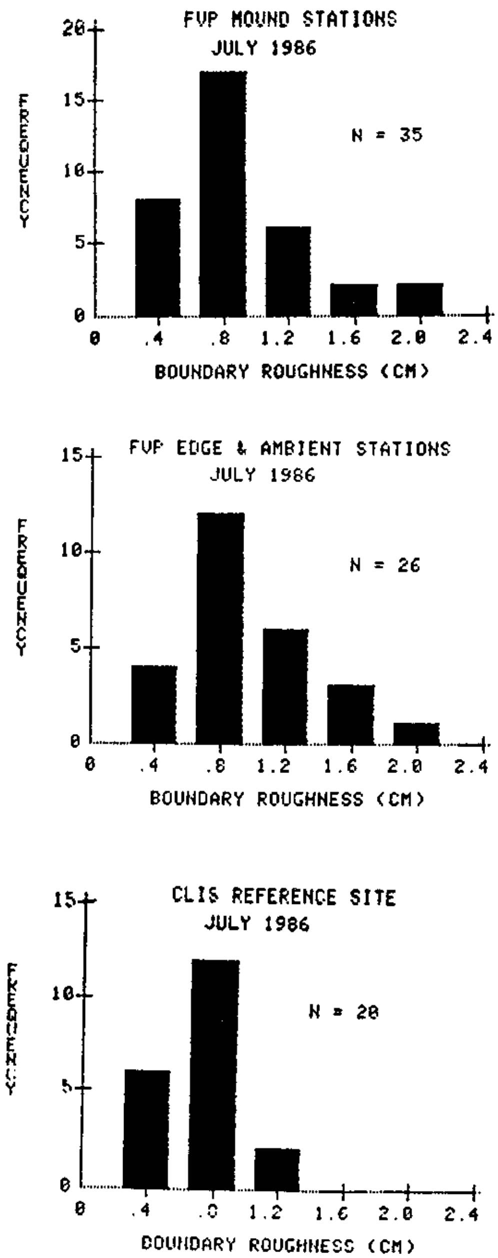


Figure 3-20. Frequency distributions of small-scale boundary roughness for all replicates at the FVP mound stations, FVP edge and ambient stations and the new CLIS reference station (n = sample size).

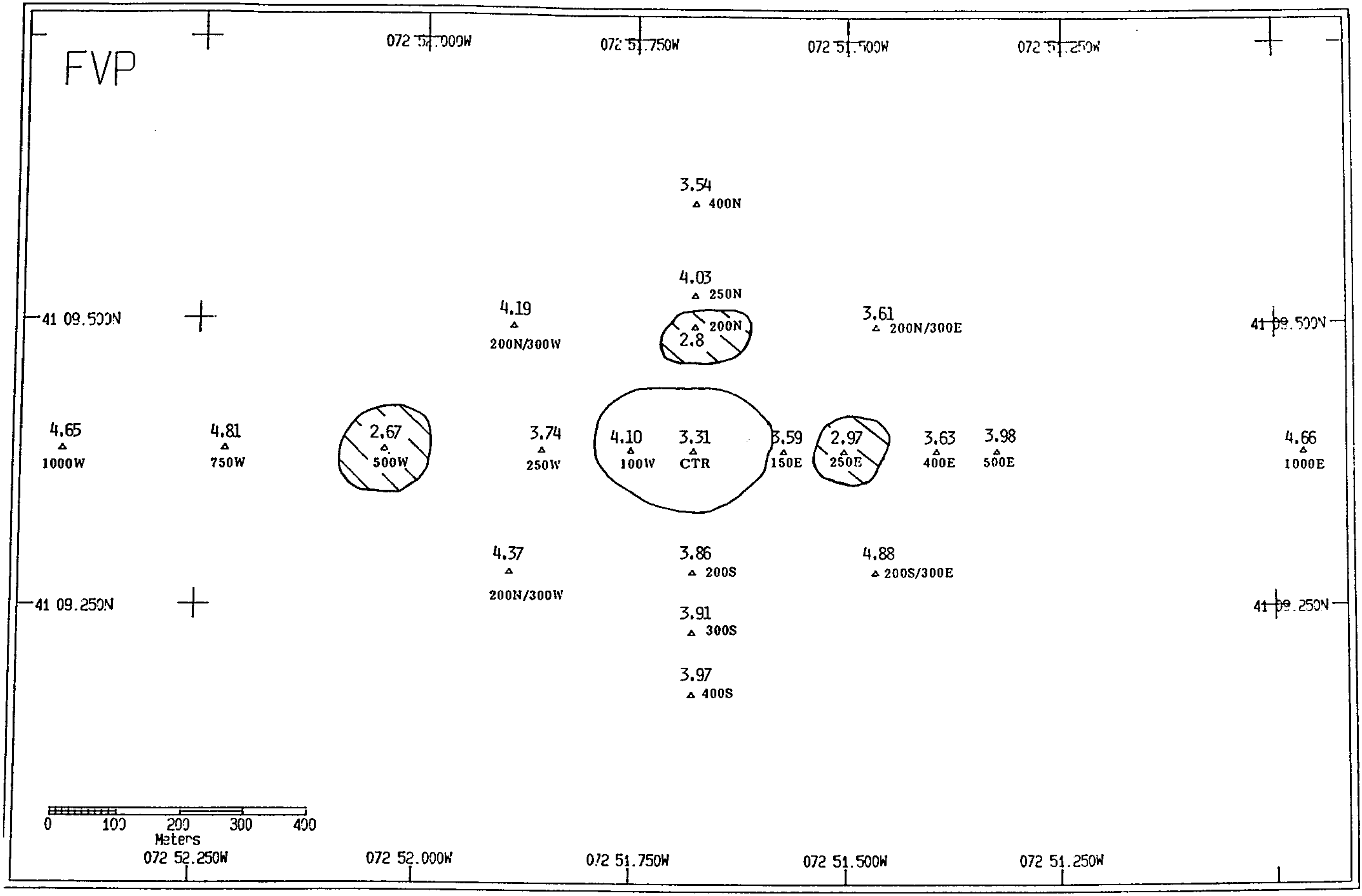


Figure 3-21. The mapped distribution of mean apparent RPD depths at the FVP disposal mound, July 1986. Hatched area had RPD depths less than or equal to 3 cm. Solid line shows mound "footprint" based on bathymetry.

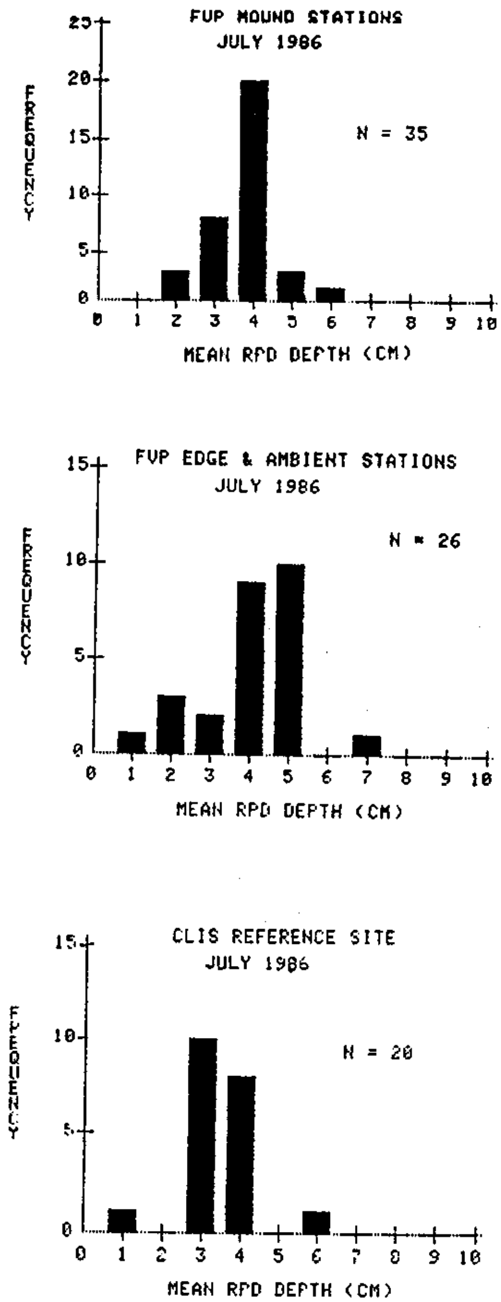


Figure 3-22. Frequency distributions of apparent RPD depths for all replicates at the FVP mound stations, FVP edge and ambient stations and the new CLIS reference station (n = sample size).

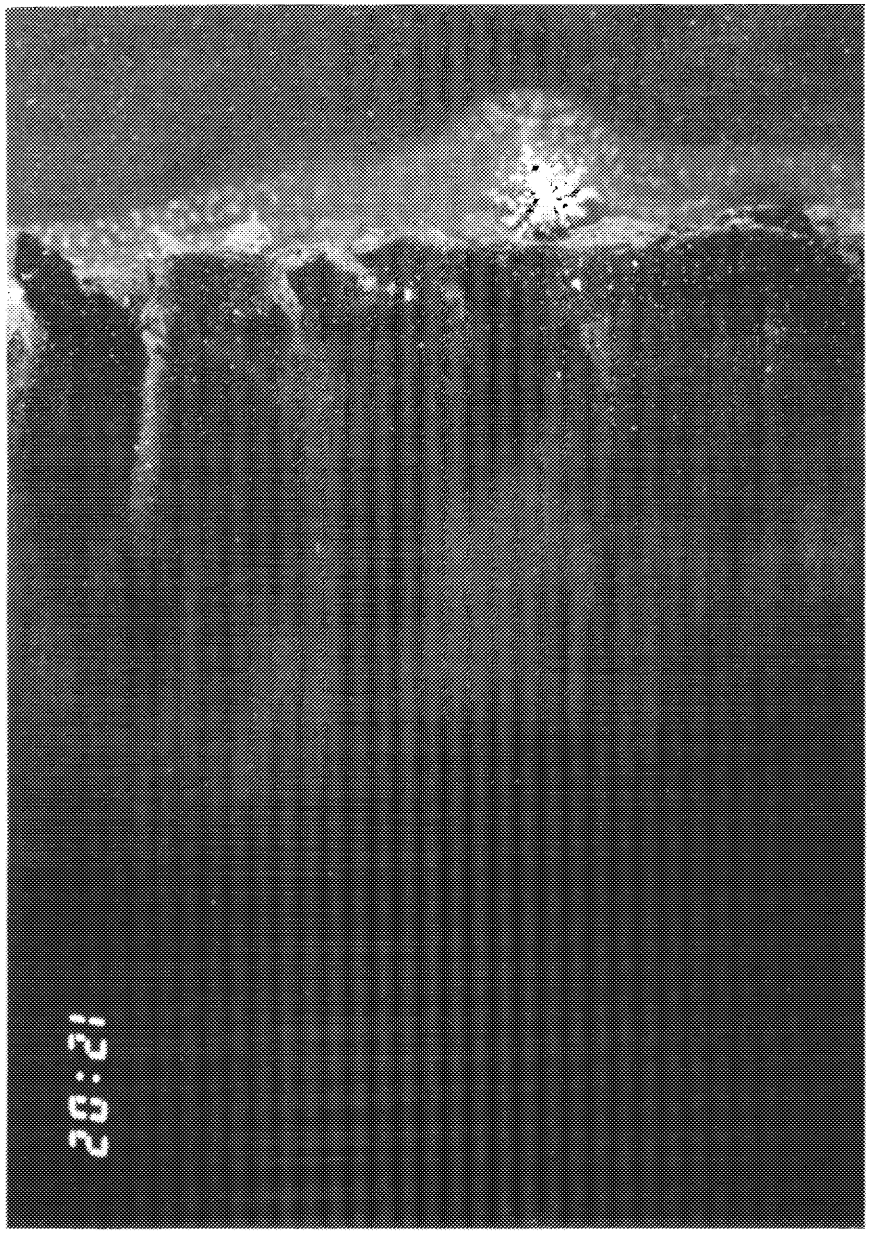


Figure 3-23a. REMOTS® image from station 150E at FVP illustrating the trend toward deeper RPD depths between October 1985 and July 1986. Image A from the October 1985 (post-hurricane) survey shows highly reduced apparent dredged material at the sediment water interface. Note starfish on surface of sediment. Scale = 1X.

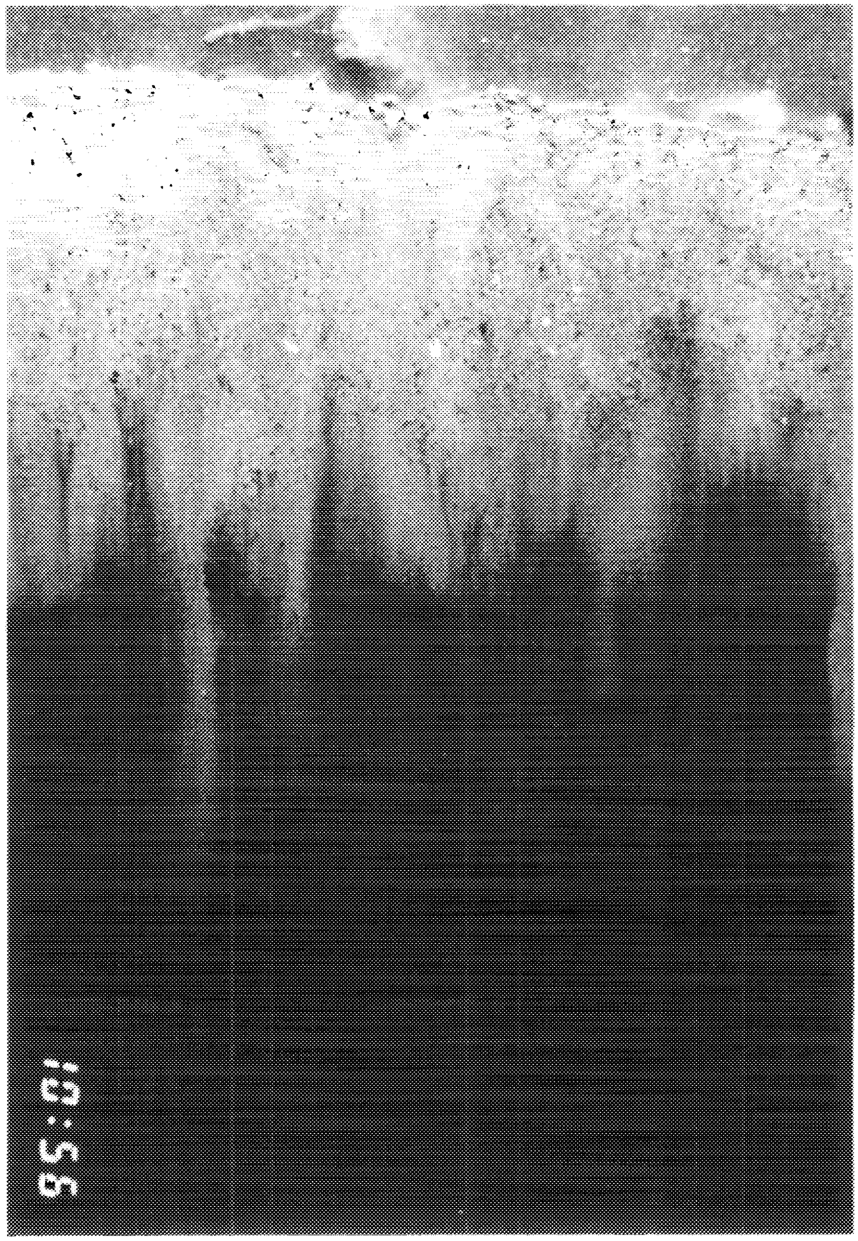


Figure 3-23b. REMOTS® images from station 150E at FVP illustrating the trend toward deeper RPD depths between October 1985 and July 1986. Image B from the July 1986 survey shows that a relatively deep RPD has again become established at this station. Scale = 1X.

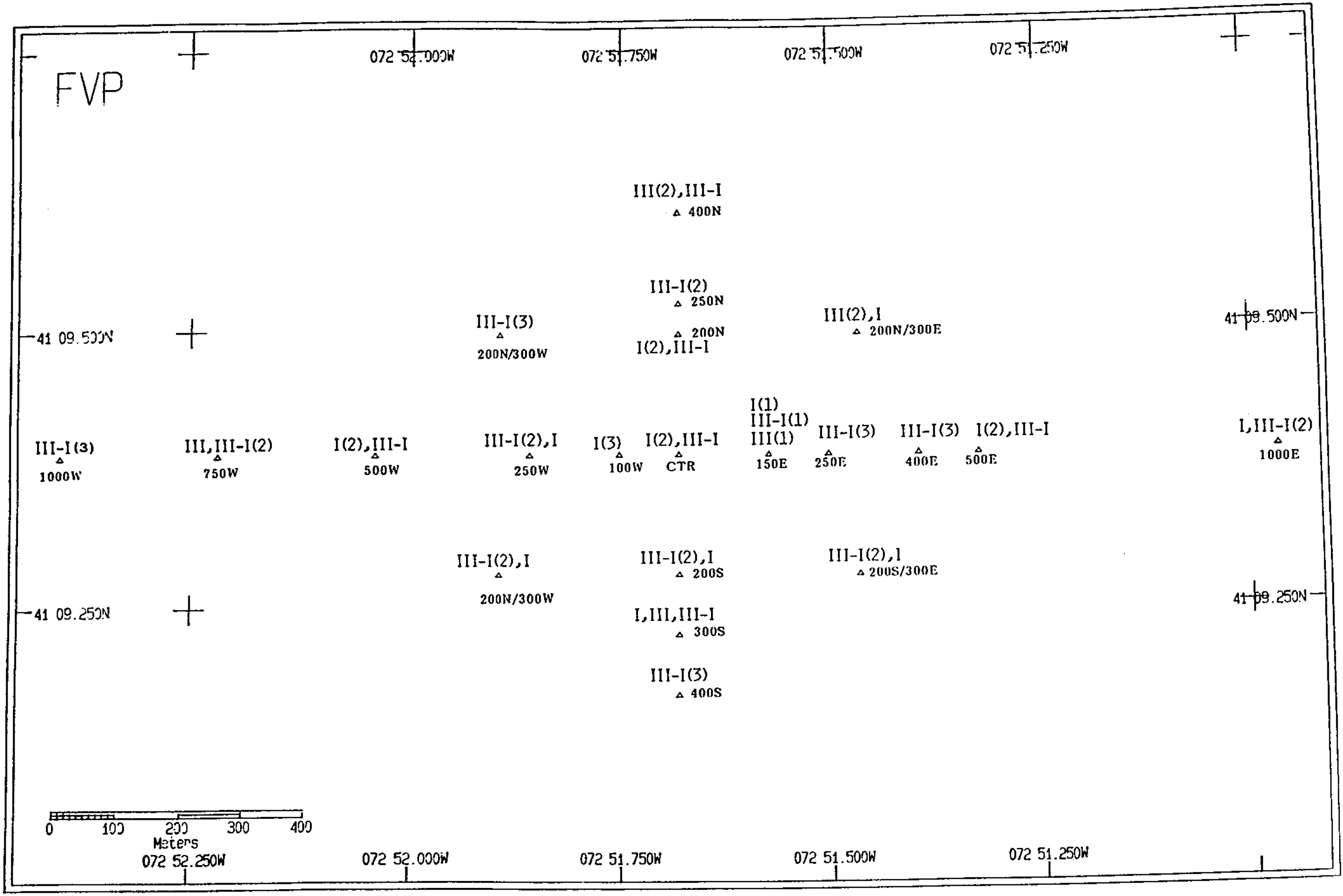


Figure 3-24. The mapped distribution of infaunal successional stages for all replicates at the FVP disposal mound, July 1986. The number of replicates exhibiting a particular successional stage is indicated in parentheses where applicable.

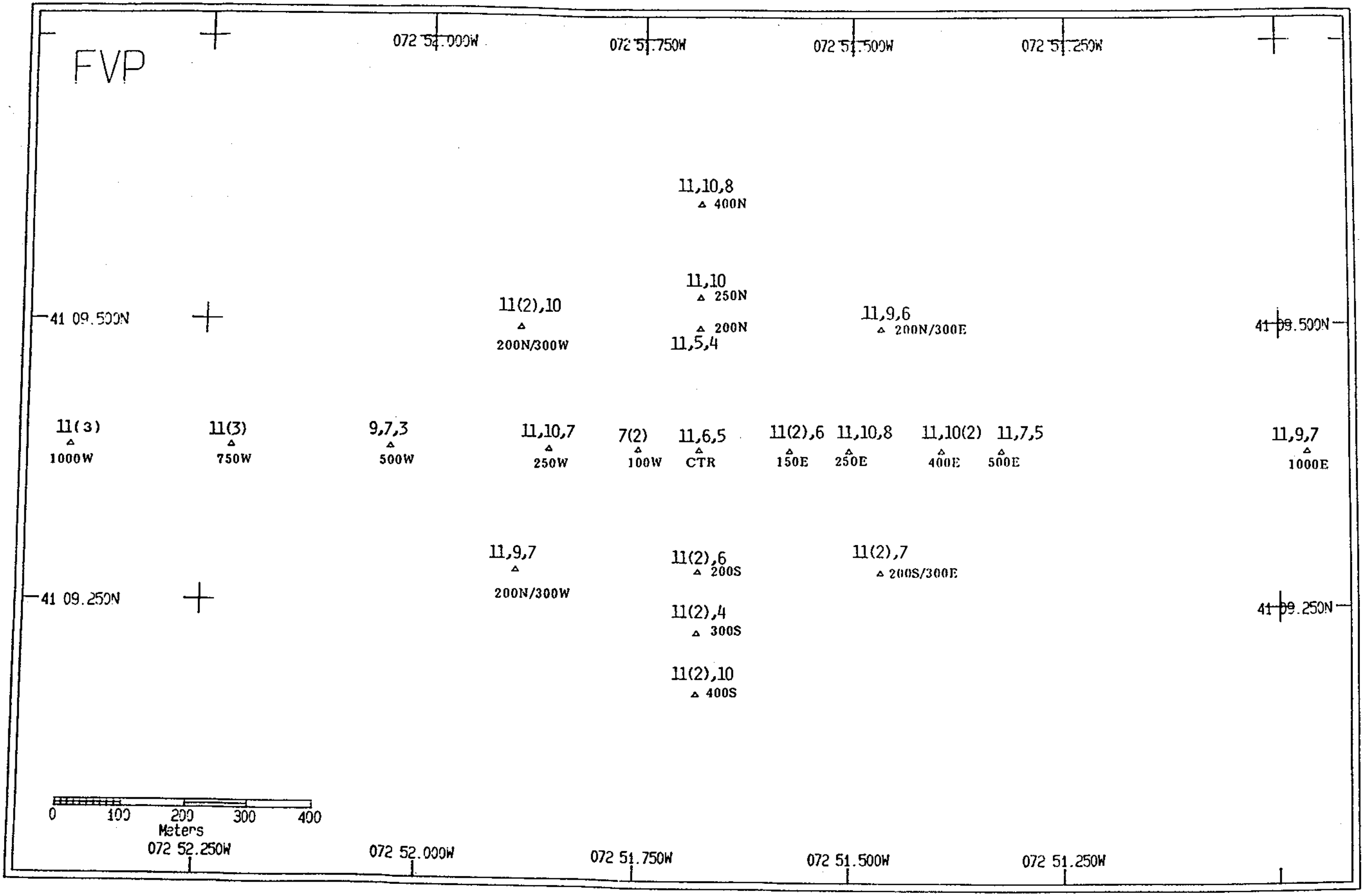


Figure 3-25. The mapped distribution of REMOTS® Organism-Sediment Indices (OSI's) for all replicates at the FVP disposal mound, July 1986. The number of replicates having a particular OSI value is indicated in parentheses where applicable.

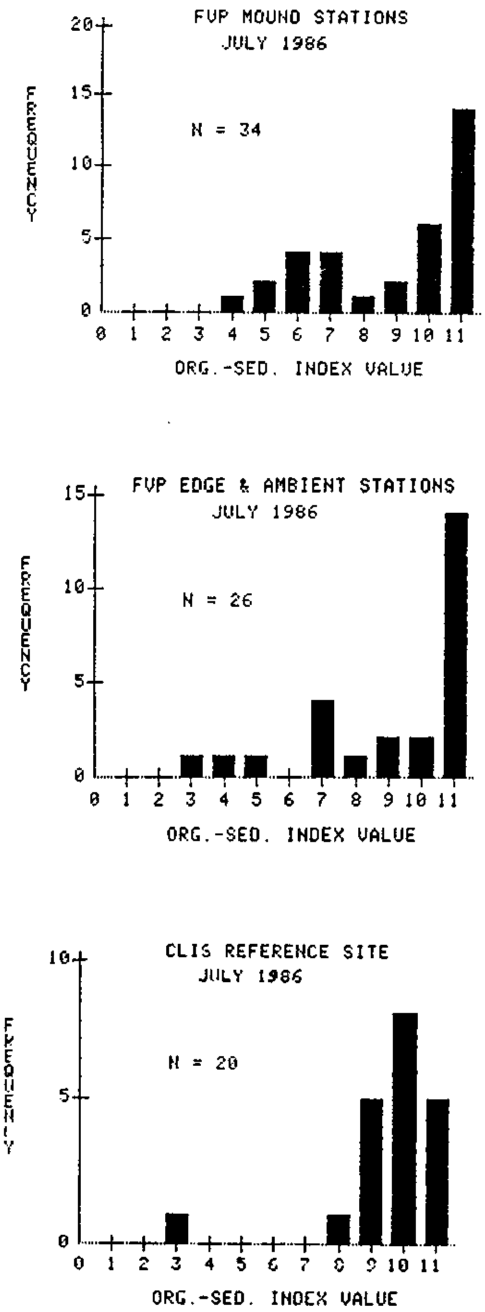


Figure 3-26. Frequency distributions of REMOTS® Organism-Sediment Indices for all replicates at the FVP mound stations, FVP edge and ambient stations and the new CLIS reference station (n = sample size).

Figure 3-27. A post-Hurricane Gloria benthic "process" map showing the distribution of erosional and depositional features at the STNH-N disposal mound in November 1985. No value indicates the absence of these features (From SAIC, 1986c). Symbols are defined as follows:

BF = Bedform

MC = Mudclast

SHELL = Shell lag deposits

-# = Estimate of erosion (cm) based on exposed worm tubes

STNH-N

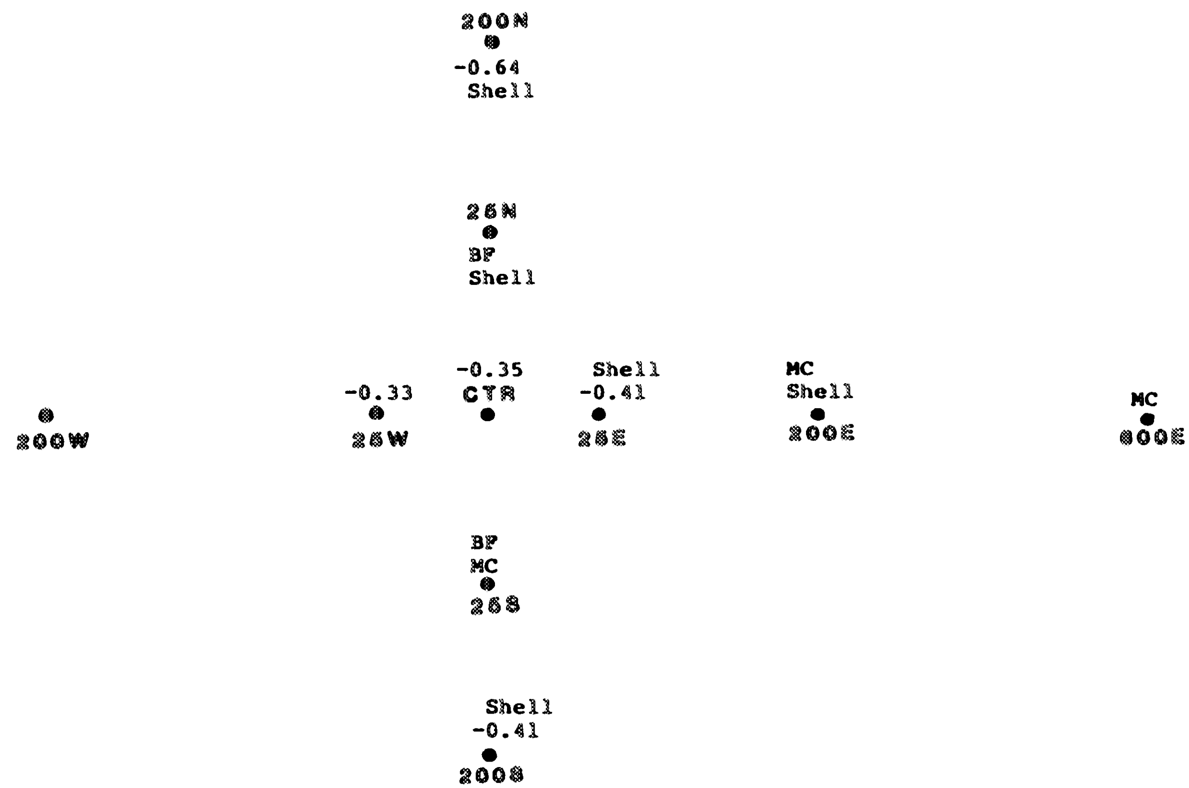


Figure 3-27.

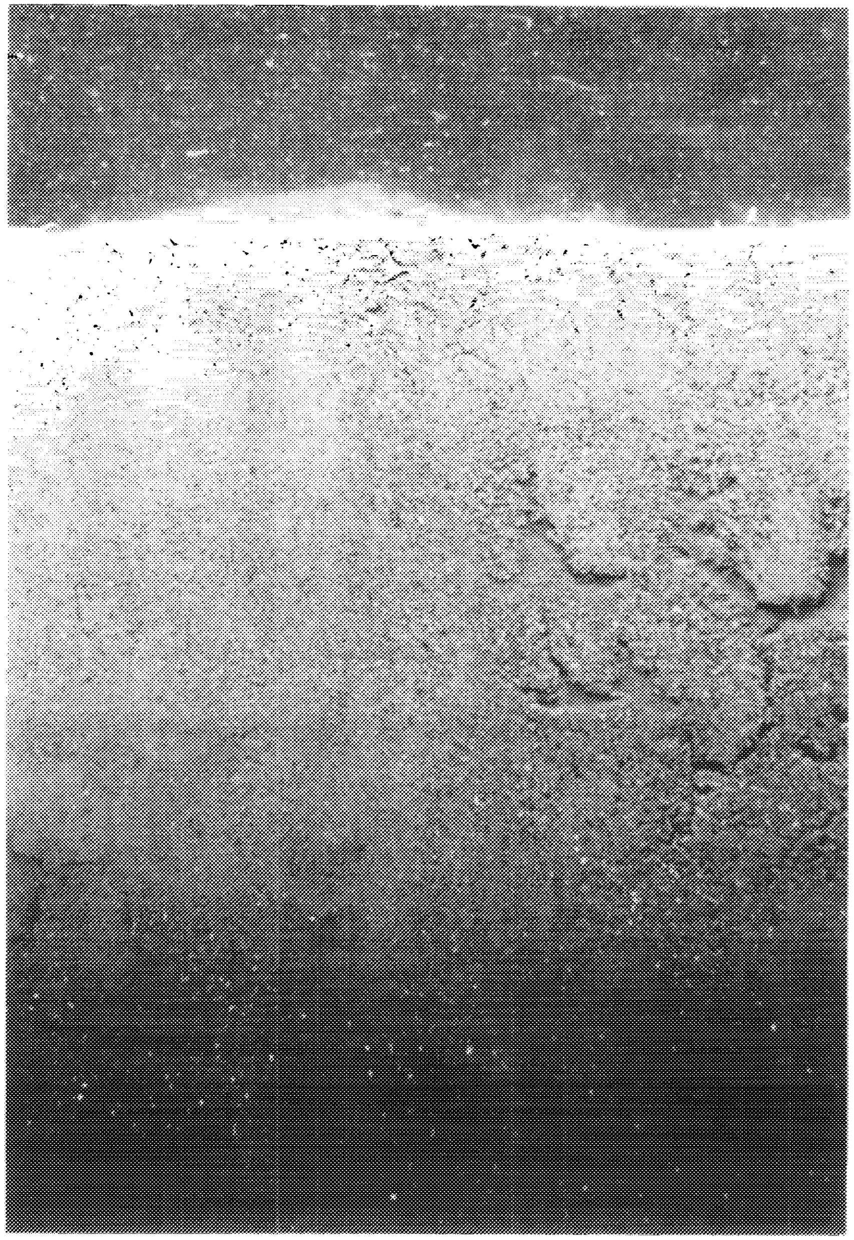


Figure 3-28. REMOTS® image from station Center at STNH-N showing intact sand cap. Note that feeding voids (which help indicate the depth of bioturbational mixing) occur above the underlying mud, suggesting that mixing between the layers is not taking place. Scale = 1X.

Figure 3-29. Benthic "process" map indicating the distribution and thickness (cm) of apparent dredged material at the STNH-N site in July 1986. Dashed and/or solid lines delimit the extent of apparent dredged material. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

SHELL = Shell lag deposits

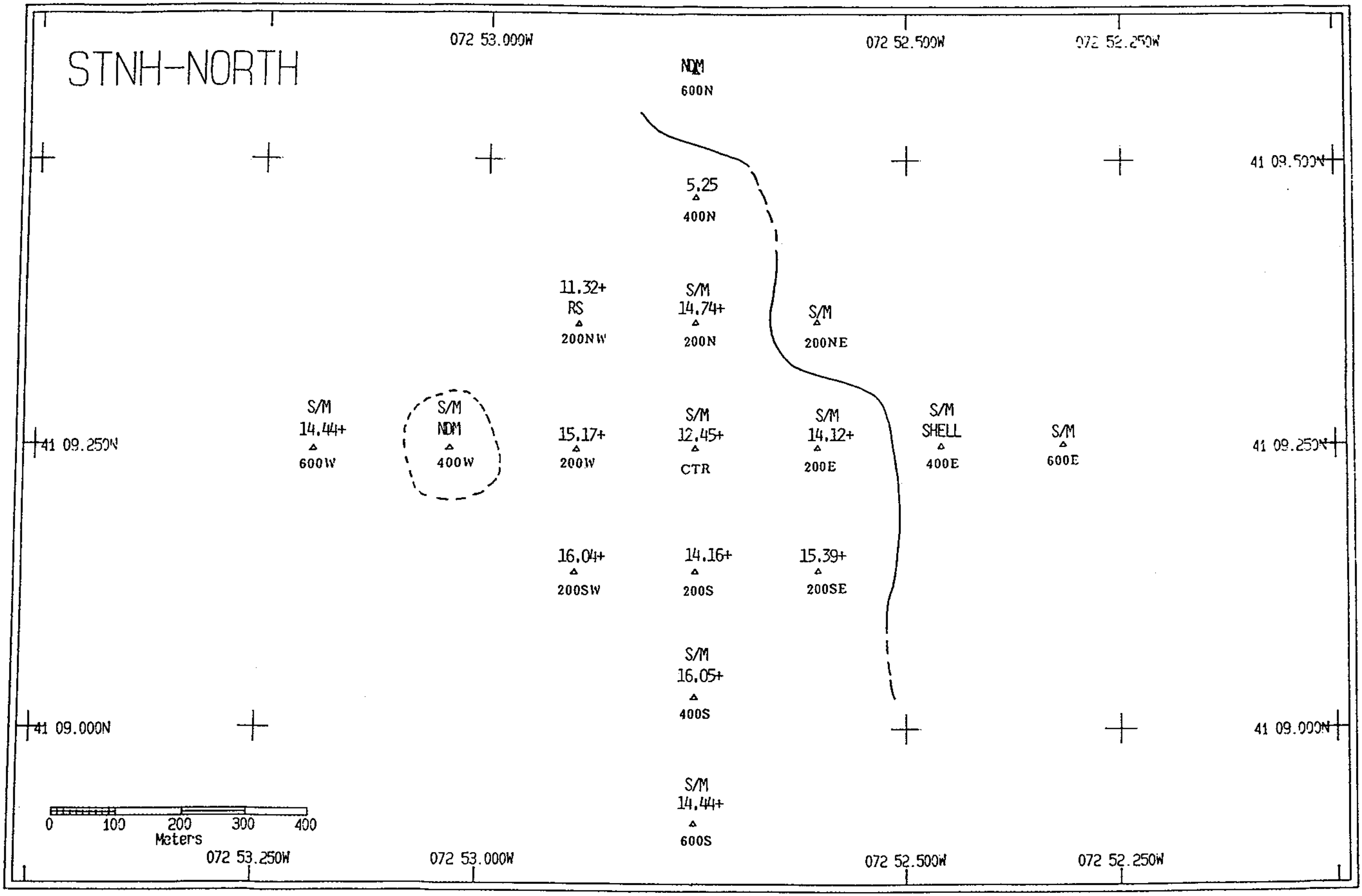

STNH-NORTH
072 53.000W
072 52.500W
072 52.250W
41 09.500N
41 09.250N
41 09.000N
072 53.250W
NDM
600N
5.25
400N
11.32+
RS
200NW
S/M
14.74+
200N
S/M
200NE
S/M
14.44+
600W
S/M
NDM
400W
15.17+
200W
S/M
12.45+
CTR
S/M
14.12+
200E
S/M
SHELL
400E
S/M
600E
16.04+
200SW
14.16+
200S
15.39+
200SE
S/M
16.05+
400S
S/M
14.44+
600S
0
100
200
300
400
Meters

Figure 3-29.

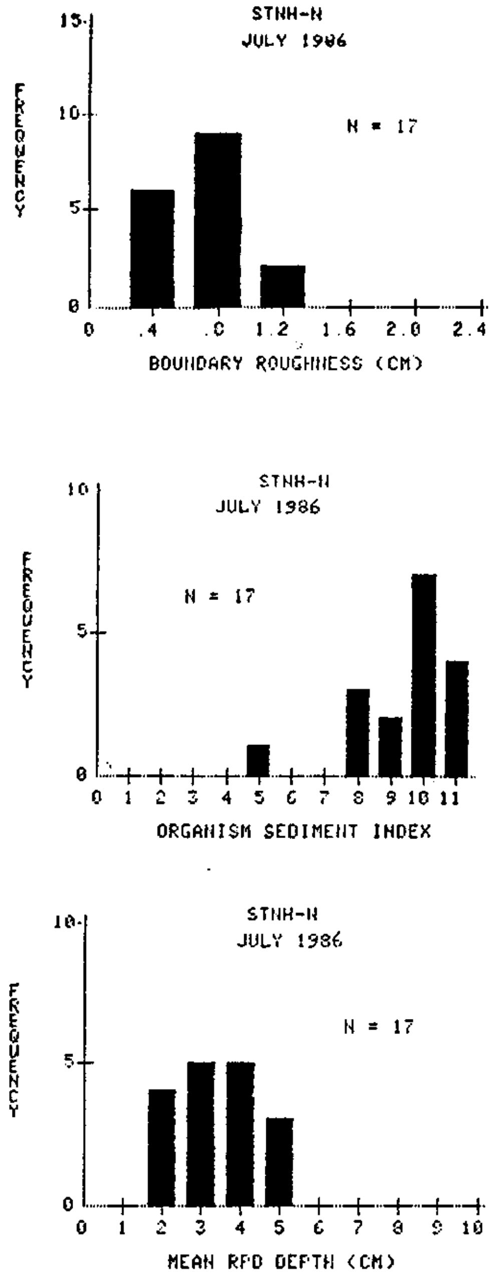


Figure 3-30. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the STNH-N disposal mound, July 1986.

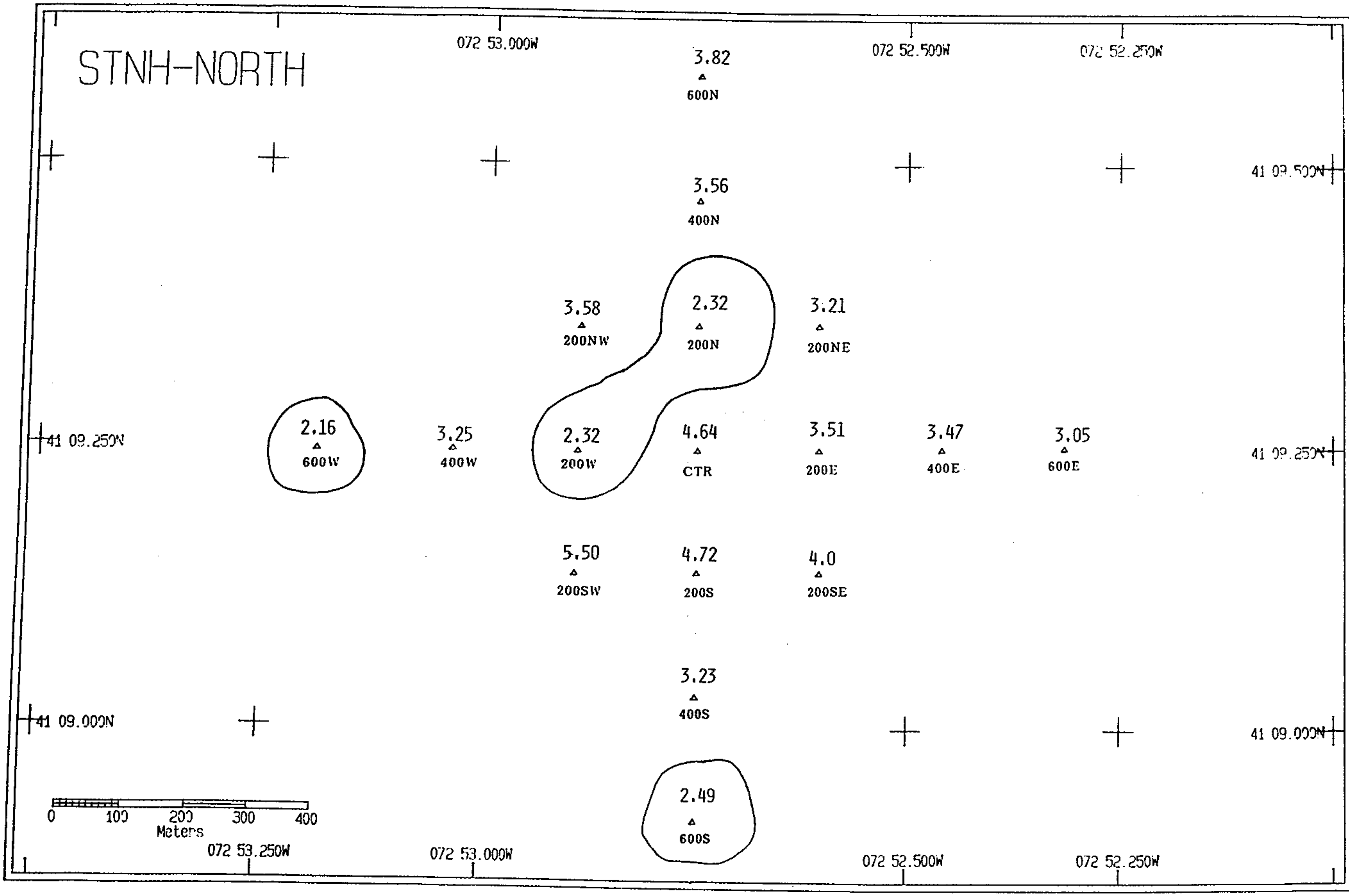


Figure 3-31. The mapped distribution of mean apparent RPD depths at the STNH-N disposal mound, July 1986. Solid lines delimit stations having mean apparent RPD depths equal to or less than 3 cm.

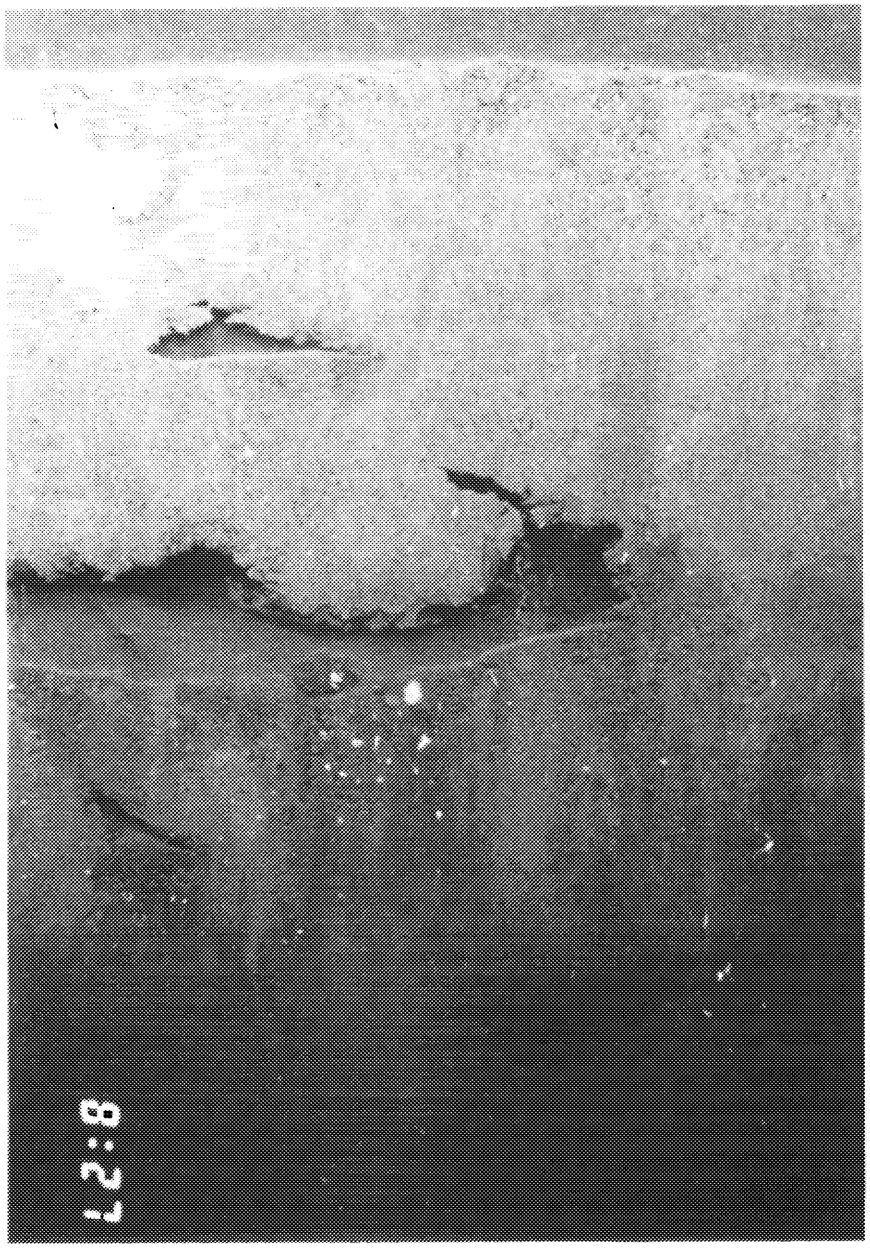


Figure 3-32. REMOTS® image from station 200SW showing well-developed Stage III feeding voids which characterize most stations at the STNH-N mound. Deep bioturbational mixing may be responsible for the apparent "disappearance" of the sand cap at such stations. Scale = 1X.

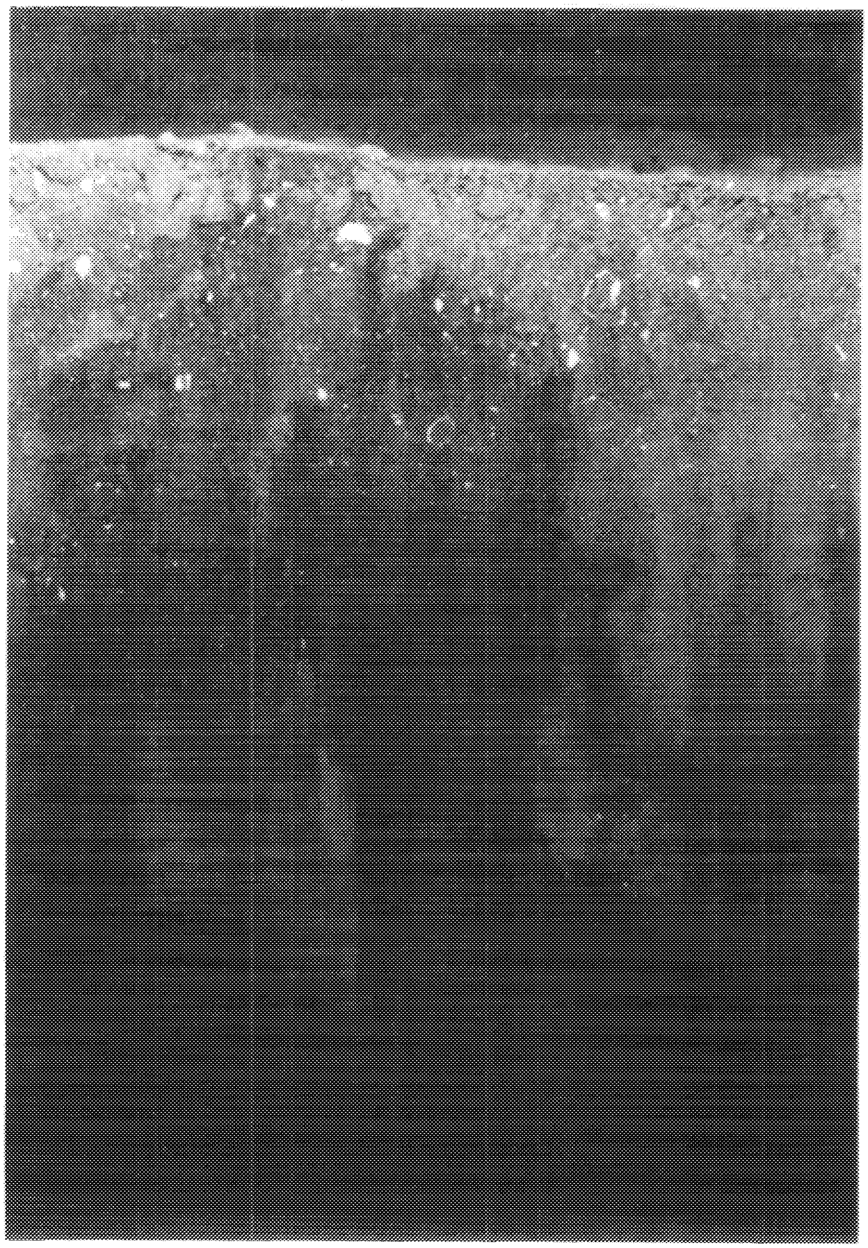


Figure 3-33. REMOTS® image from station 200W showing an apparent absence of head-down deposit feeders. The mean apparent RPD depth is correspondingly shallow at this station (2-3 cm). Scale = 1X.

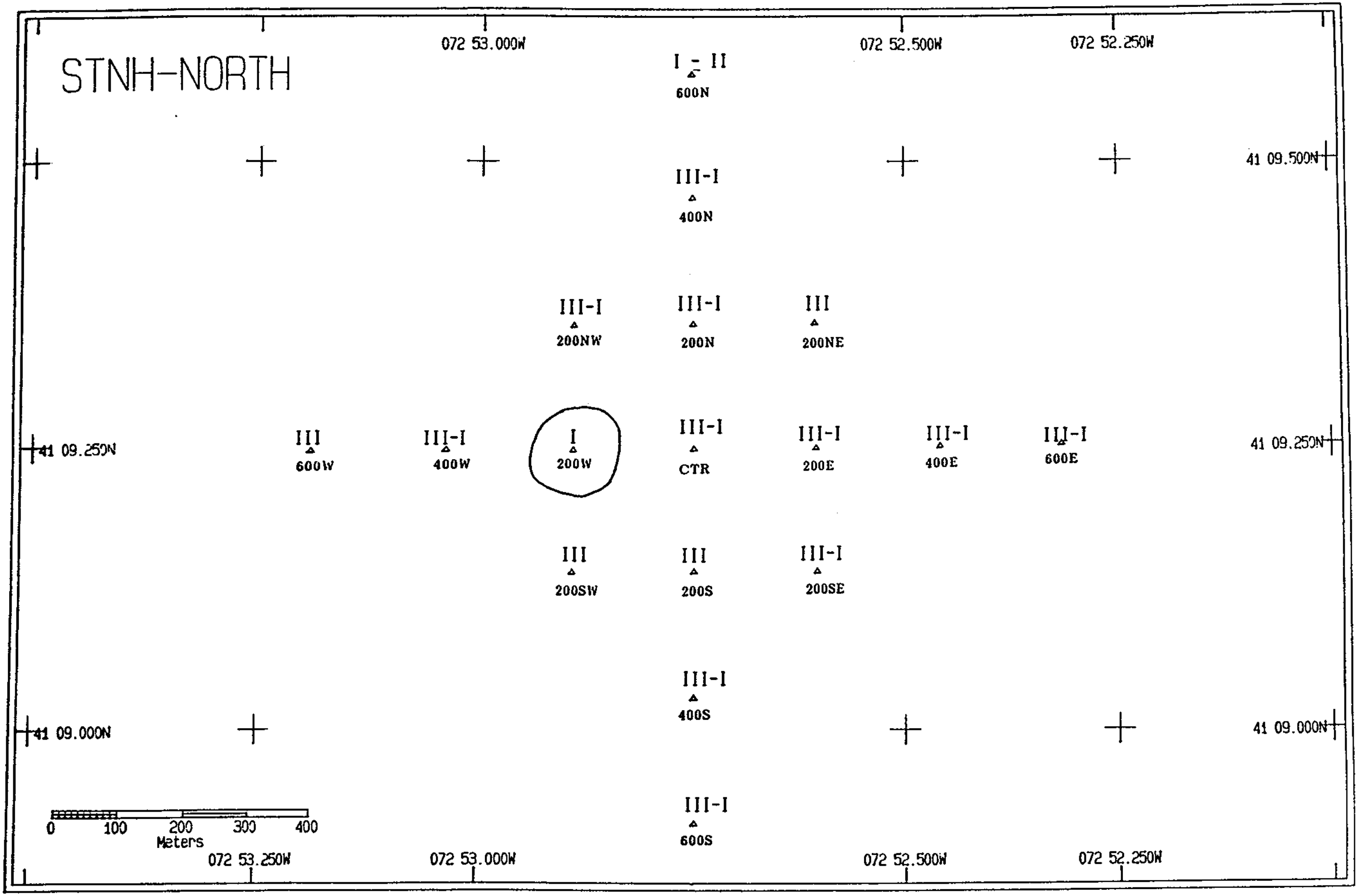


Figure 3-34. The mapped distribution of infaunal successional stages at the STNH-N disposal mound, July 1986. Solid line delimits station having only Stage I sere.

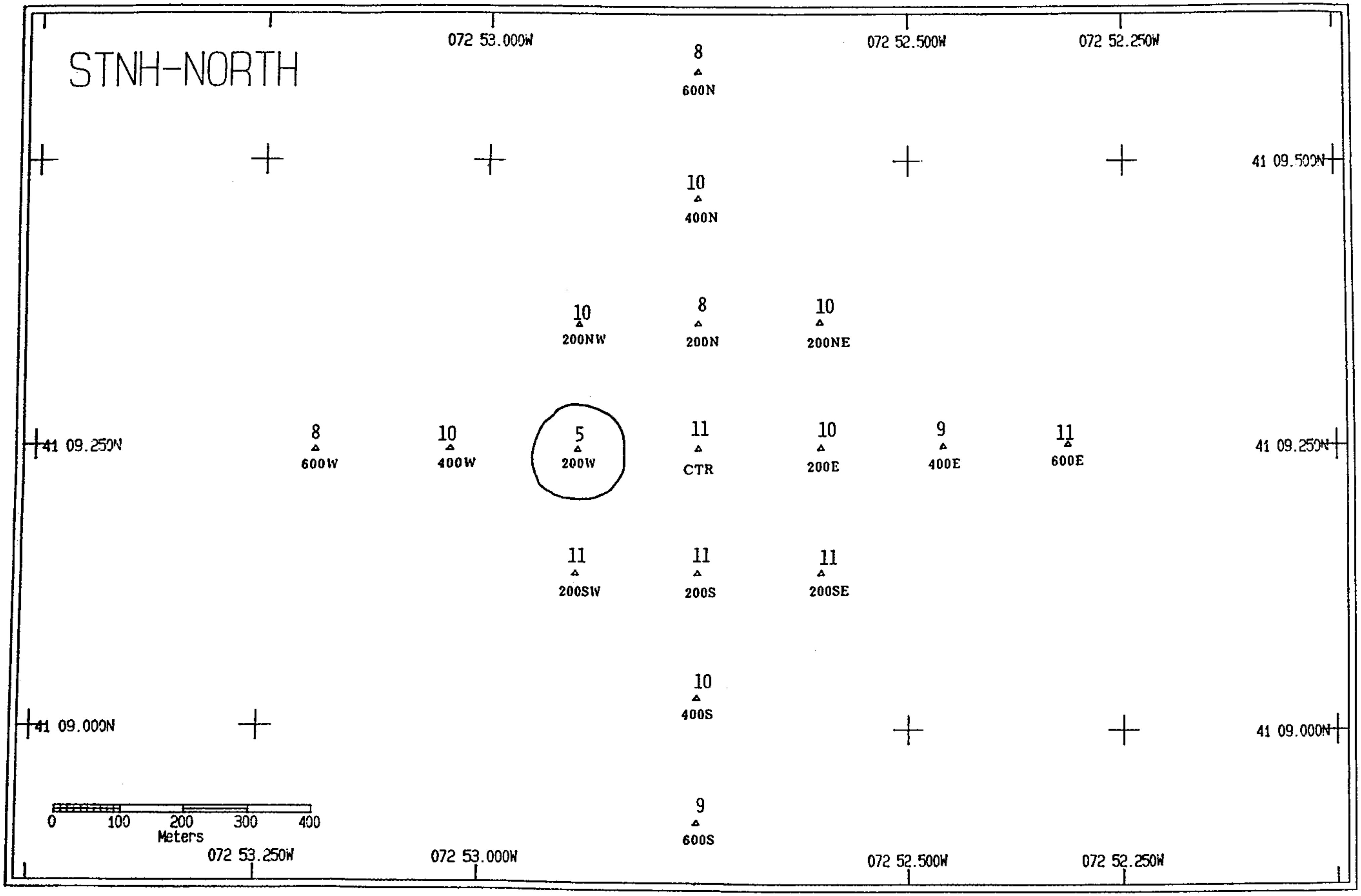


Figure 3-35. The mapped distribution of REMOTS® Organism-Sediment Indices (OSI's) at the STNH-N disposal mound, July 1986. Solid line delimits station having OSI value less than +6.

Figure 3-36. Benthic "process" map which indicates the distribution and thickness (cm) of apparent dredged material at the STNH-S disposal mound in July 1986. Solid and/or dashed lines delimit the extent of dredged material. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

SHELL = Shell lag deposits

DK/LT/DK = Low reflectance sediment over high reflectance sediment over low reflectance sediment.

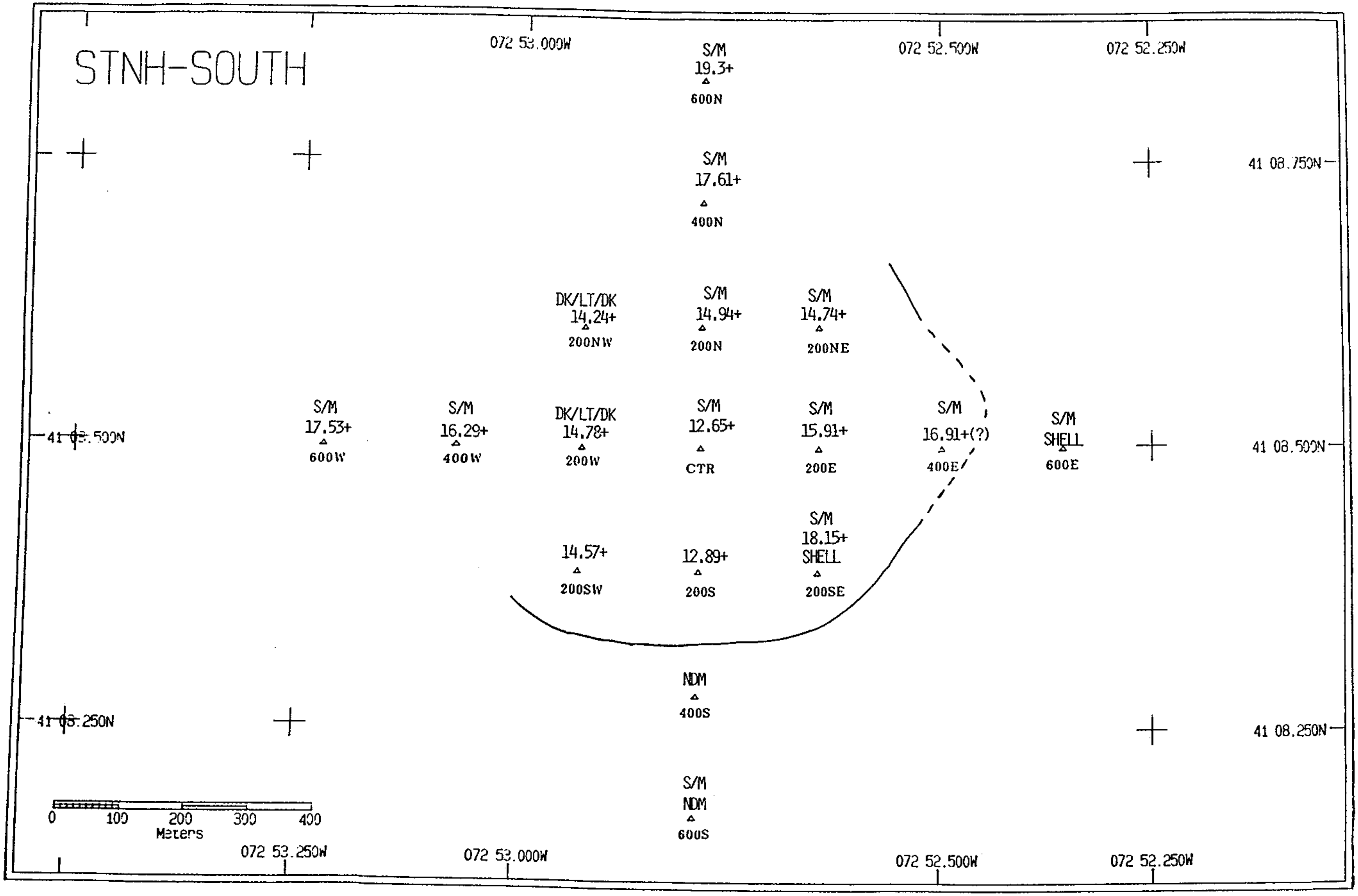

STNH-SOUTH
072 53.000W
072 52.500W
072 52.250W
S/M
19.3+
600N
S/M
17.61+
400N
41 08.750N
DK/LT/DK
14.24+
200NW
S/M
14.94+
200N
S/M
14.74+
200NE
S/M
17.53+
600W
S/M
16.29+
400W
DK/LT/DK
14.78+
200W
S/M
12.65+
CTR
S/M
15.91+
200E
S/M
16.91+(?)
400E
S/M
SHELL
600E
41 08.500N
14.57+
200SW
12.89+
200S
S/M
18.15+
SHELL
200SE
NDM
400S
41 08.250N
S/M
NDM
600S
0
100
200
300
400
Meters
072 53.250W
072 53.000W
072 52.500W
072 52.250W

Figure 3-36.

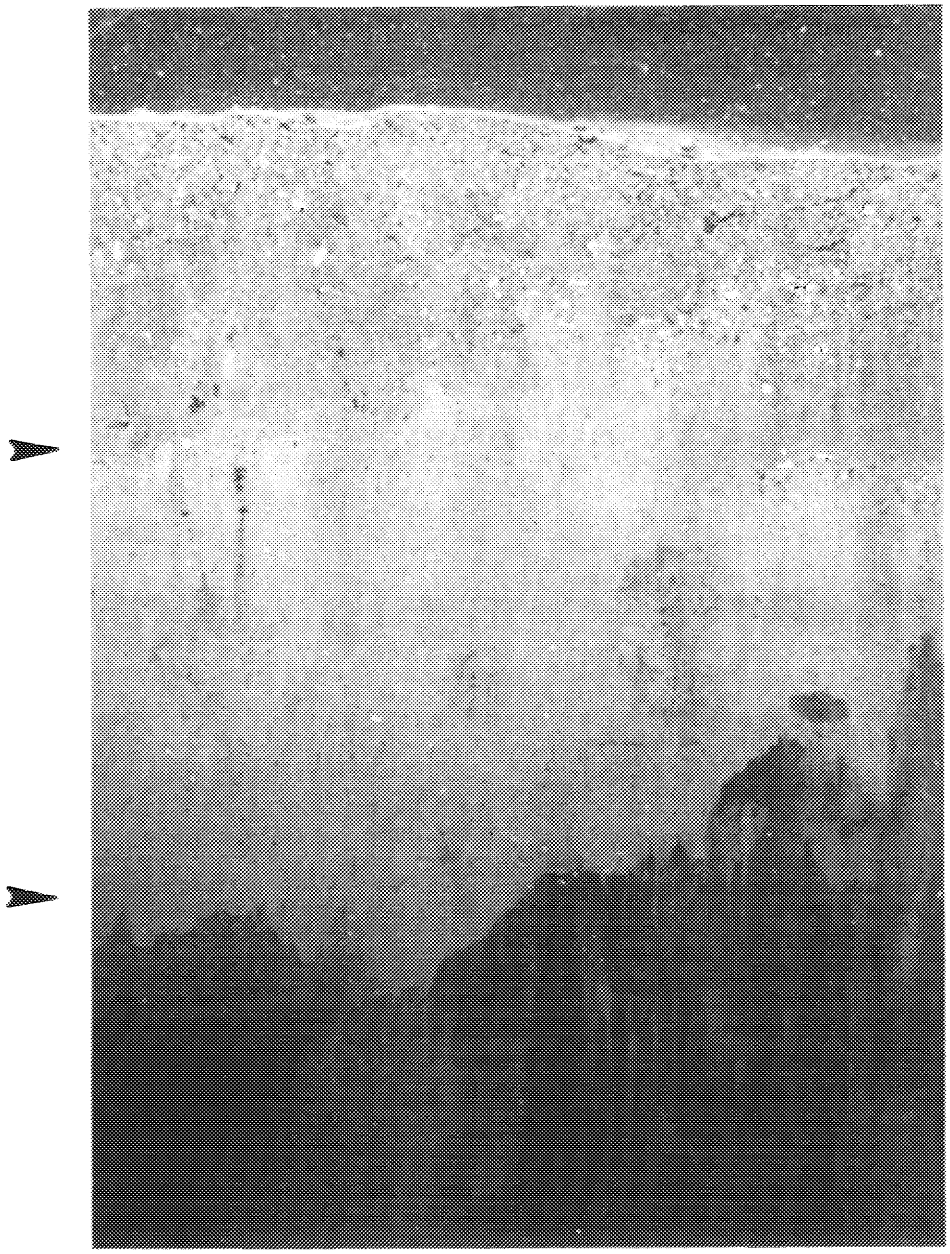


Figure 3-37a. REMOTS® image from station 200W showing similar stratigraphy to 200NW. Sediment has intermediate reflectance overlying high reflectance sediment which in turn overlies low reflectance sediment. Arrows point to boundaries between the different layers. Scale = 1X.

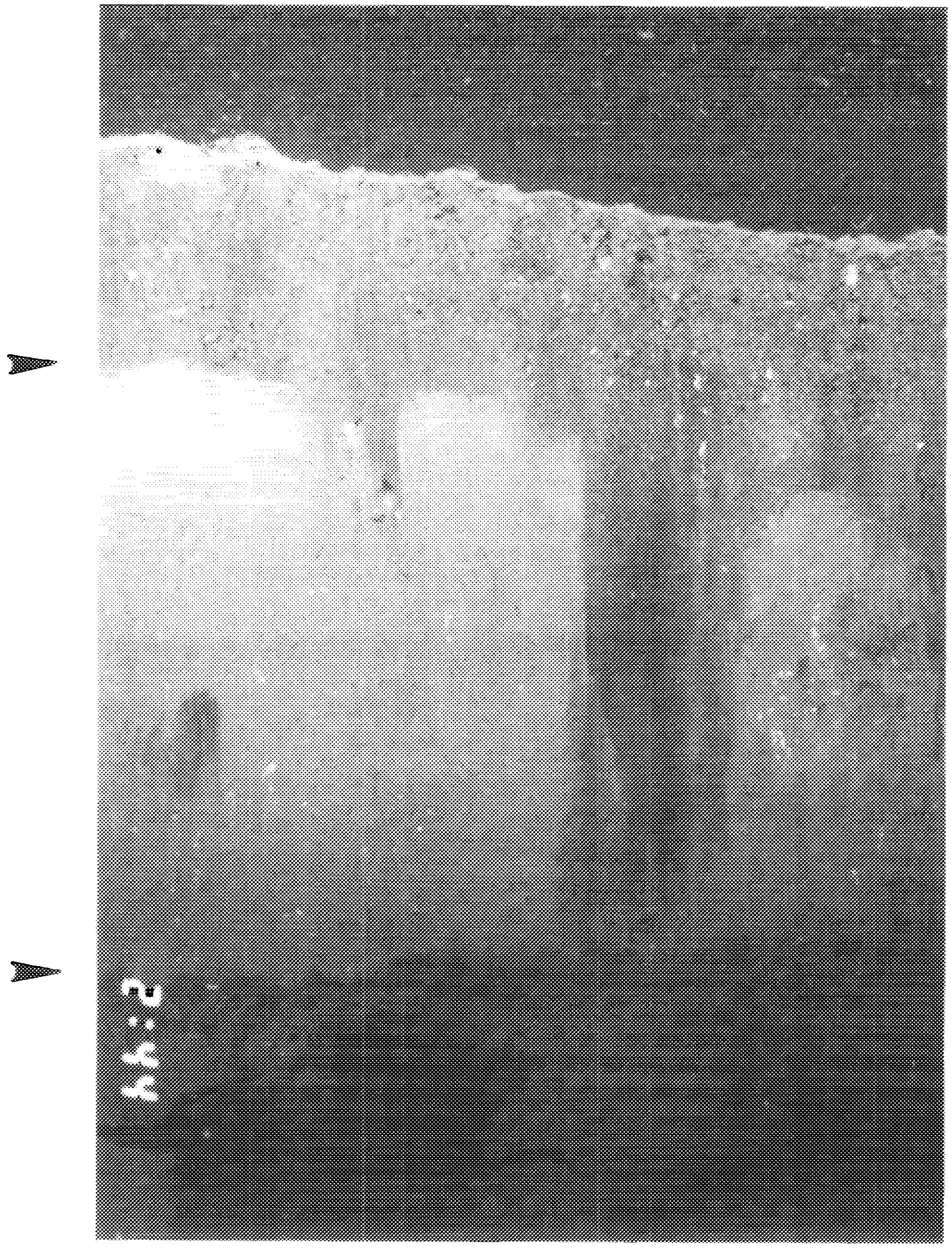


Figure 3-37b. REMOTS® image from station 200NW showing similar stratigraphy to 200N. Sediment has intermediate reflectance overlying high reflectance sediment which in turn overlies low reflectance sediment. Arrows point to boundaries between the different layers. Note the horizontal fractures in the bottom low-reflectance layer. Scale = 1X.

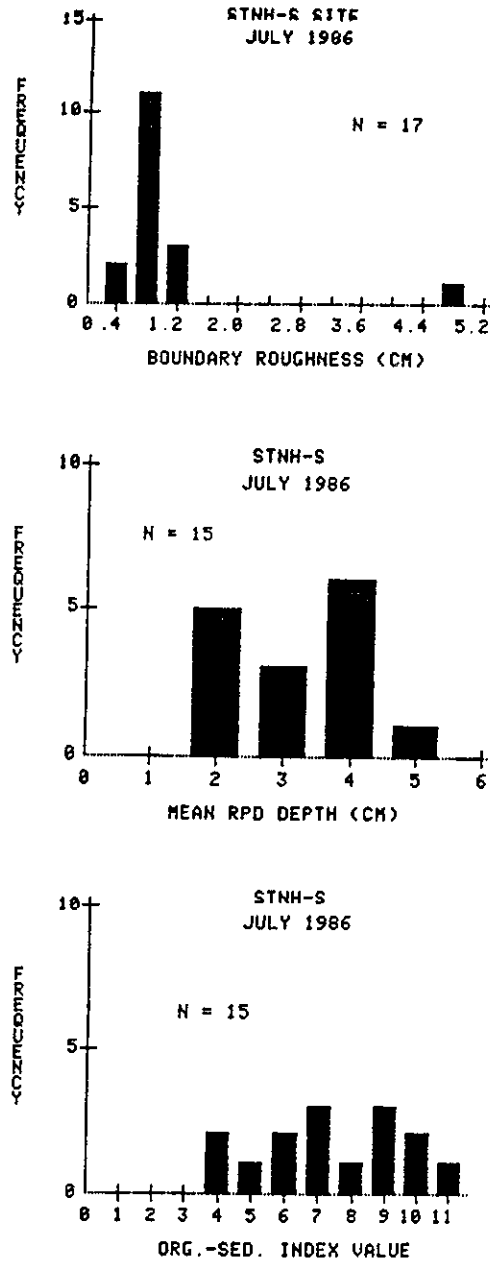


Figure 3-38. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the STNH-S disposal mound, July 1986.

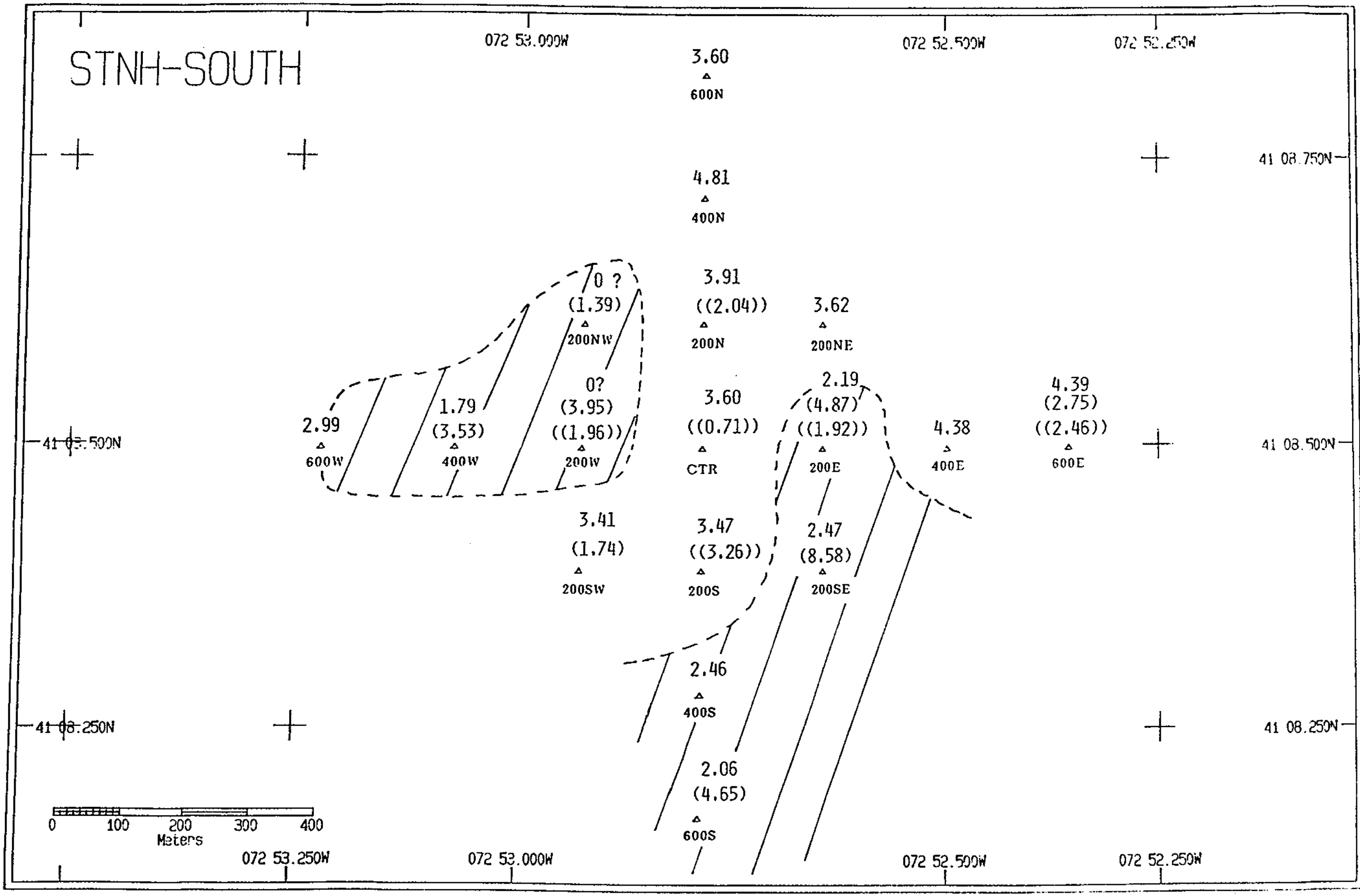


Figure 3-39. The mapped distribution of mean apparent RPD depths at the STNH-S disposal mound, July 1986. Values in parentheses are from the August 1985 survey at this mound; values in double parentheses are from the post-Hurricane Gloria survey in October 1985. Hatched areas indicate stations having mean apparent RPD depths equal to or less than 3 cm.

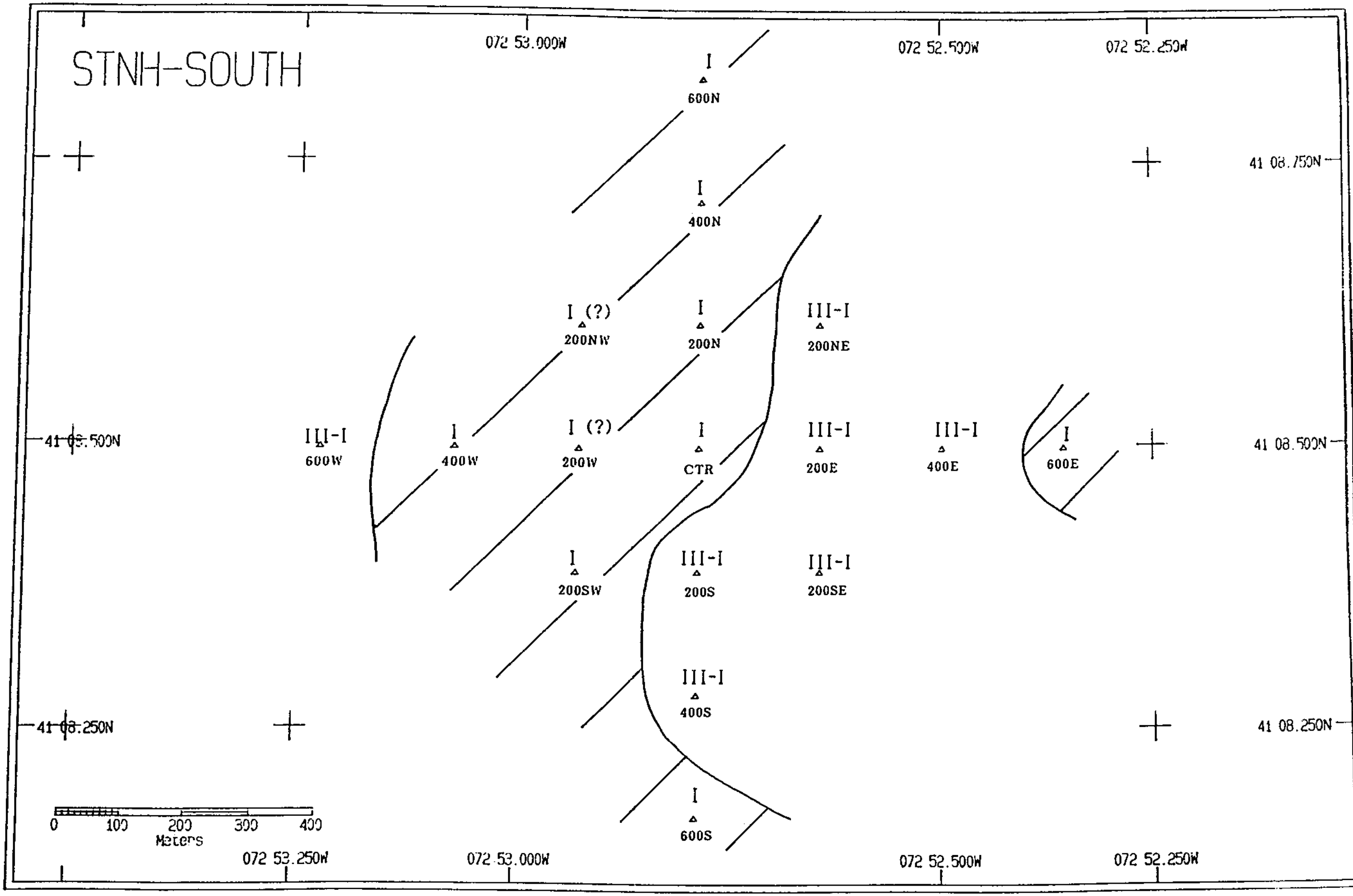


Figure 3-40. The mapped distribution of infaunal successional stages at the STNH-S disposal mound, July 1986. Hatched areas delimit stations having only Stage I sere.

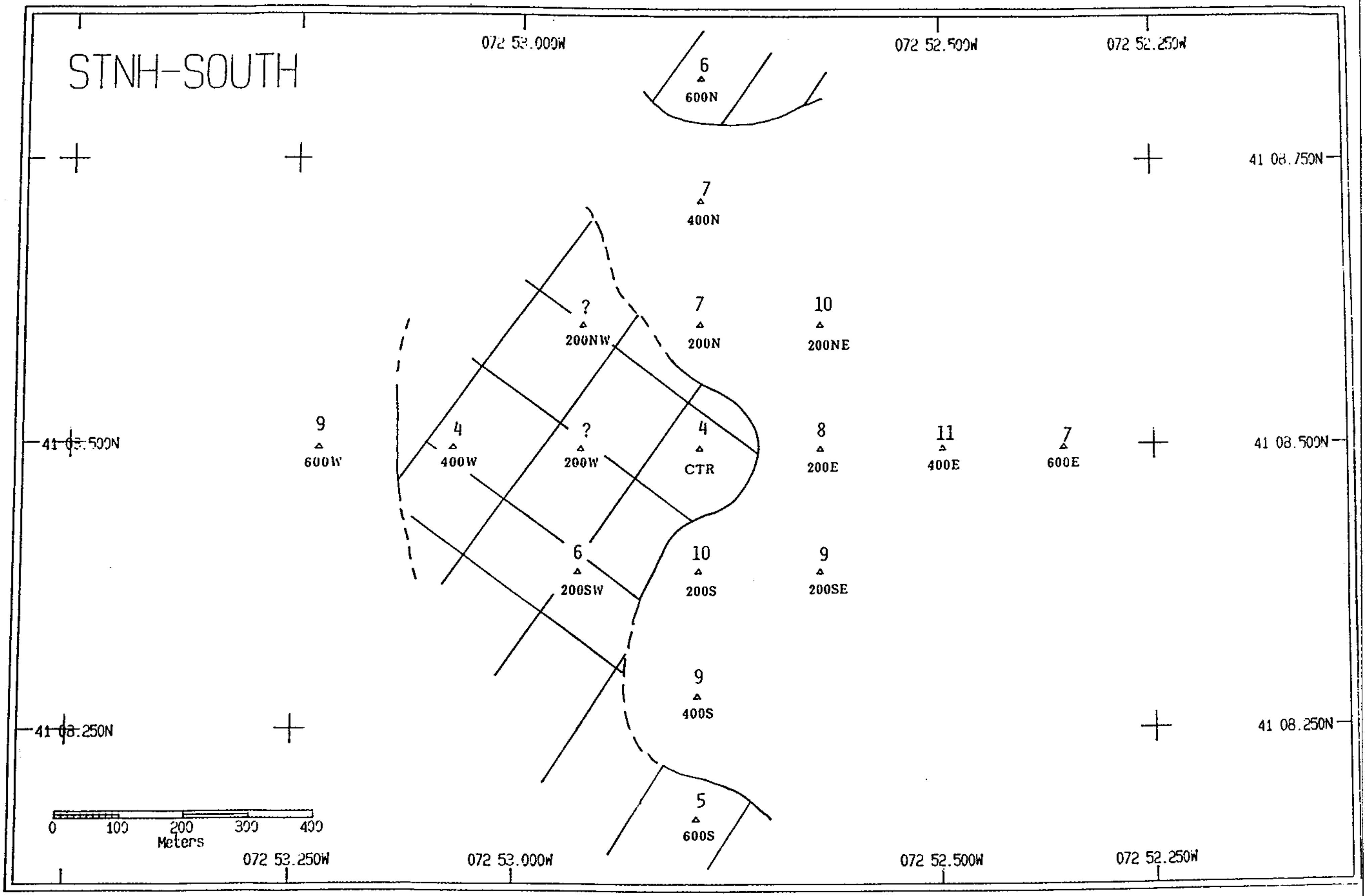


Figure 3-41. The mapped distribution of REMOTS® Organism-Sediment Indices (OSI's) at the STNH-S disposal mound, July 1986. Hatched areas delimit stations having OSI values equal to or less than +6; cross-hatched areas are those which also had OSI values of +6 or less in August 1985.

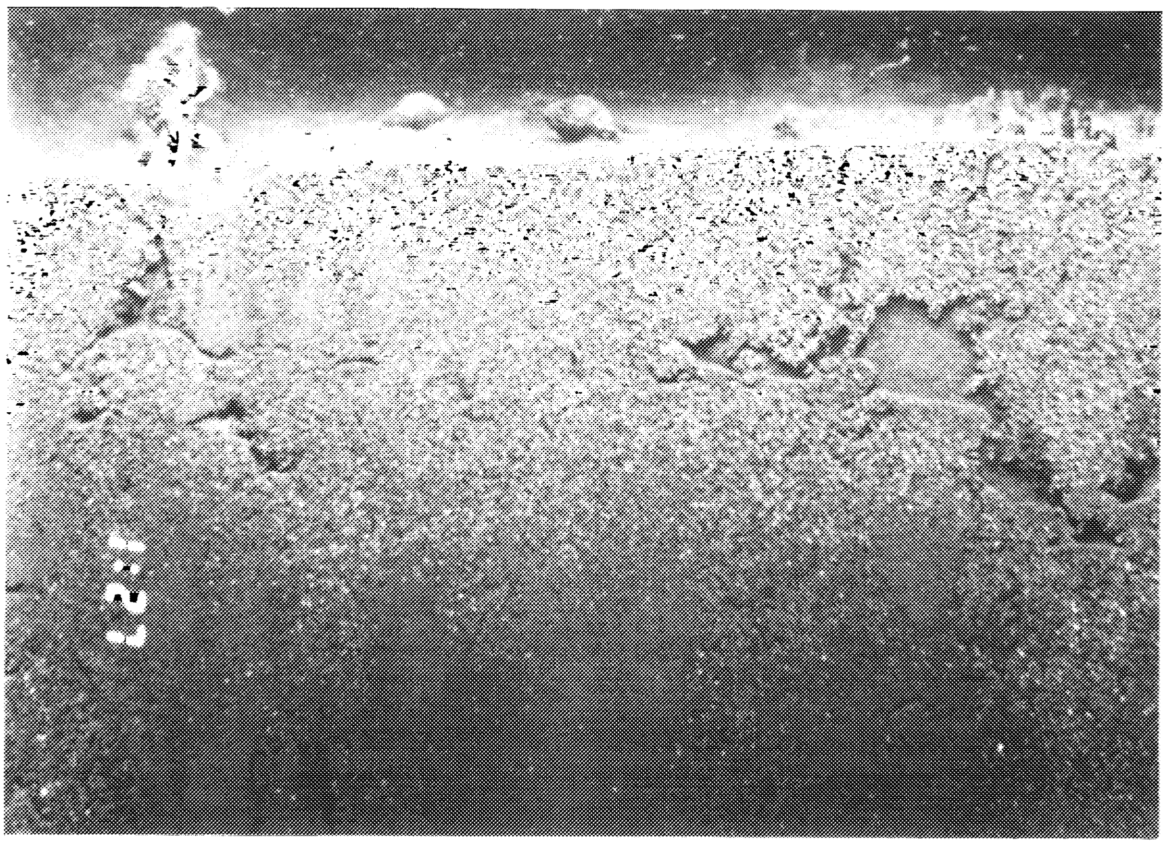


Figure 3-42. REMOTS® image from station 600N at CS-1 showing an intact sand cap. A sand over mud stratigraphy characterizes this station. Scale = 1X.

Figure 3-43. Two benthic "process" maps (A and B) which indicate the distribution and thickness (cm) of apparent dredged material at the CS-1 (A) and CS-2 (B) disposal mounds in July 1986. Solid and/or dashed lines delimit the extent of dredged material. Symbols are defined as follows:

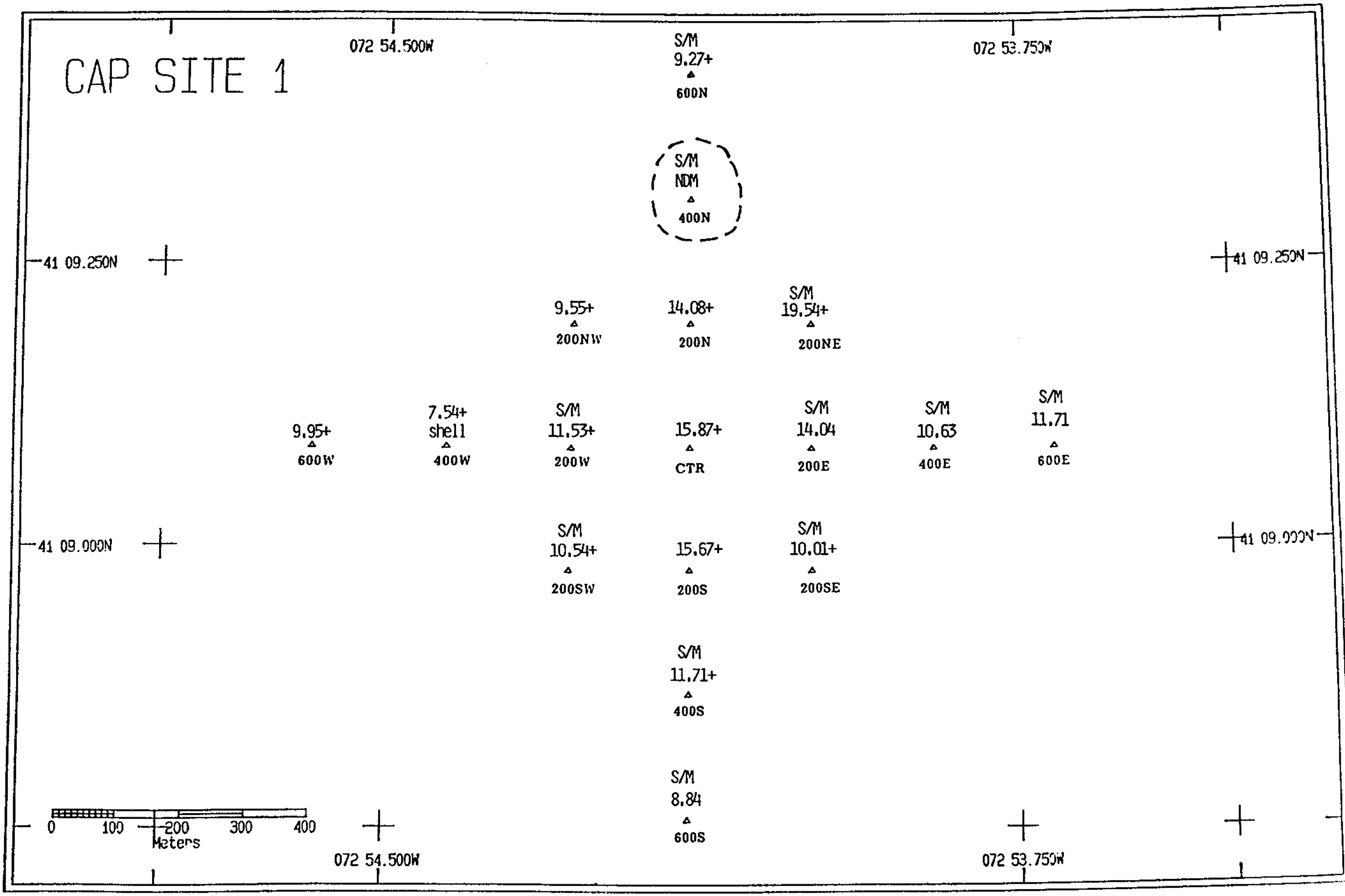
= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

SHELL = Shell lag deposits



CAP SITE 1
072 54.500W
072 53.750W
41 09.250N
41 09.000N
S/M
9.27+
600N
S/M
NDM
400N
9.55+
200NW
14.08+
200N
S/M
19.54+
200NE
9.95+
600W
7.54+
shell
400W
S/M
11.53+
200W
15.87+
CTR
S/M
14.04
200E
S/M
10.63
400E
S/M
11.71
600E
S/M
10.54+
200SW
15.67+
200S
S/M
10.01+
200SE
S/M
11.71+
400S
S/M
8.84
600S
0
100
200
300
400
Meters

Figure 3-43a

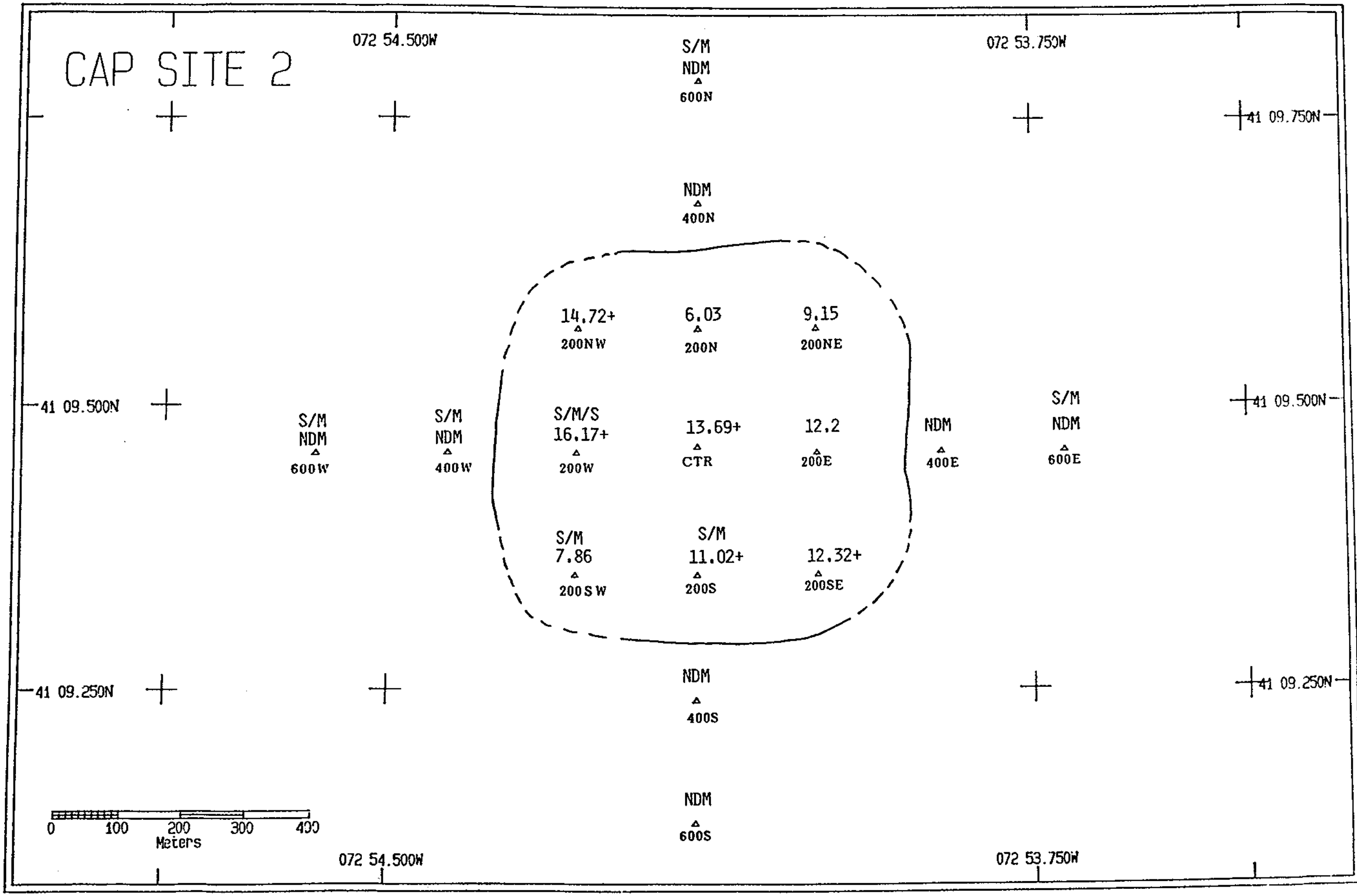

CAP SITE 2
072 54.500W
S/M
NDM
600N
072 53.750W
41 09.750N
NDM
400N
14.72+
200NW
6.03
200N
9.15
200NE
41 09.500N
S/M
NDM
600W
S/M
NDM
400W
S/M/S
16.17+
200W
13.69+
CTR
12.2
200E
NDM
400E
S/M
NDM
600E
41 09.500N
S/M
7.86
200SW
S/M
11.02+
200S
12.32+
200SE
41 09.250N
NDM
400S
41 09.250N
0
100
200
300
400
Meters
NDM
600S
072 54.500W
072 53.750W

Figure 3-43b

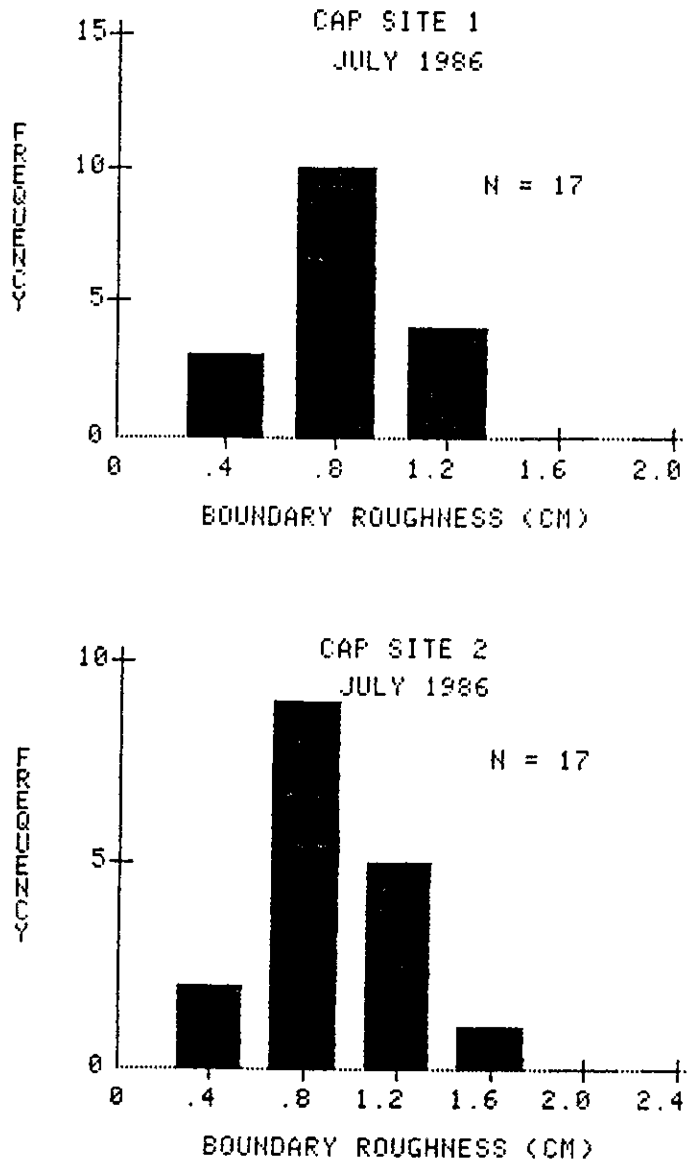


Figure 3-44. Frequency distributions of small-scale boundary roughness values at CS-1 and CS-2 in July 1986.

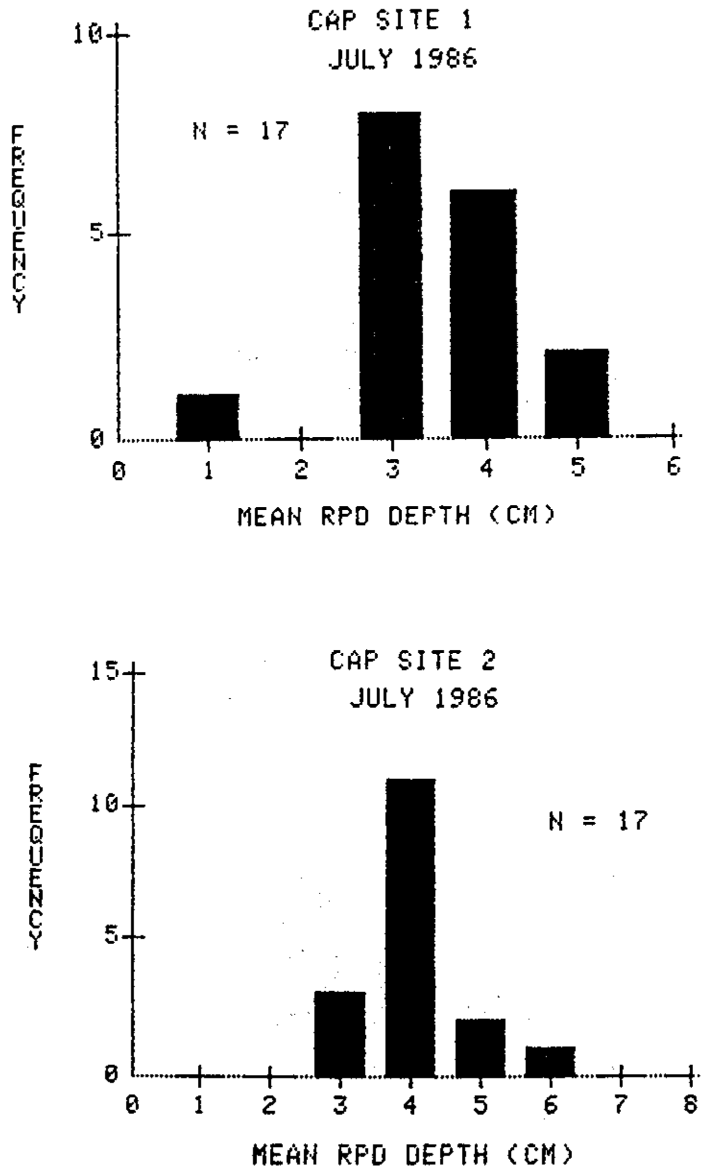


Figure 3-45. Frequency distributions of mean apparent RPD depths at CS-1 and CS-2 in July 1986.

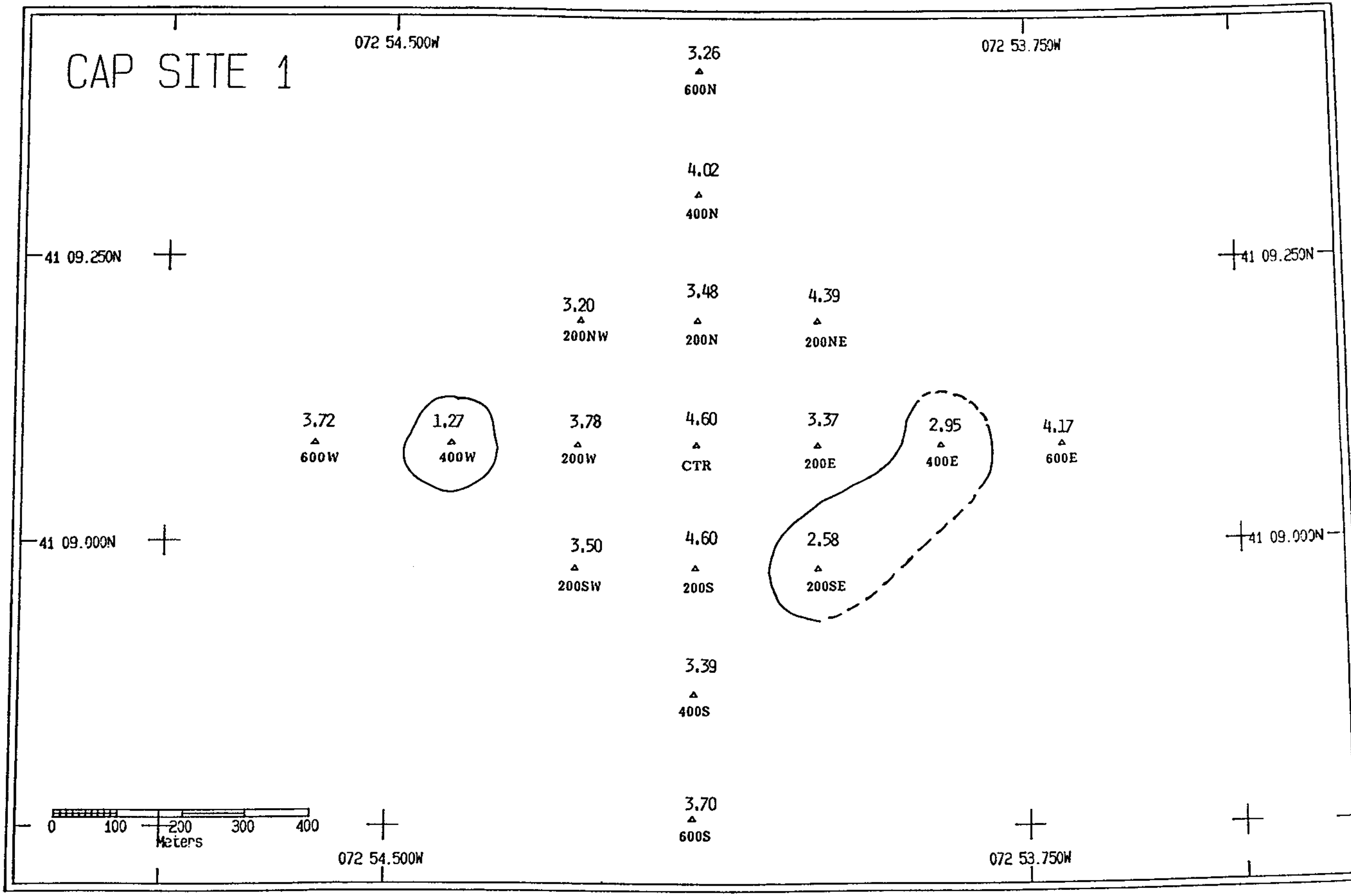


Figure 3-46a. The mapped distribution of mean apparent RPD depths at the CS-1 disposal mound in July 1986. Solid and/or dashed lines indicate stations having mean apparent RPD depths equal to or less than 3 cm.

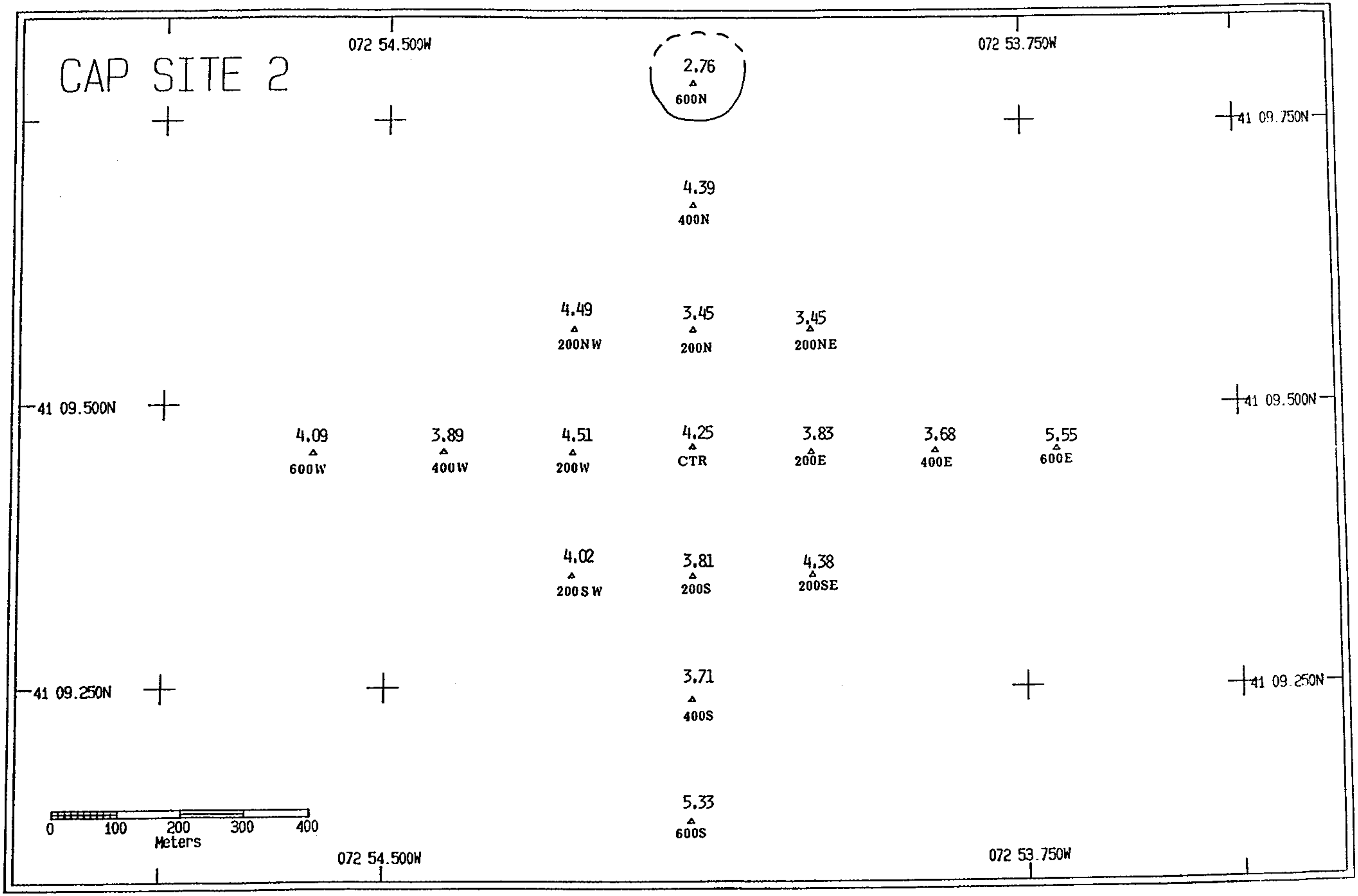


Figure 3-46b. The mapped distribution of mean apparent RPD depths at the CS-2 disposal mound in July 1986. Solid and/or dashed lines indicate stations having mean apparent RPD depths equal to or less than 3 cm.

Figure 3-47a. REMOTS® image from station Center at CS-1. The image shows deep RPD depths and feeding voids, which are evidence of Stage III taxa. This mound apex station shows no evidence of physical disturbance. Scale = 1X.

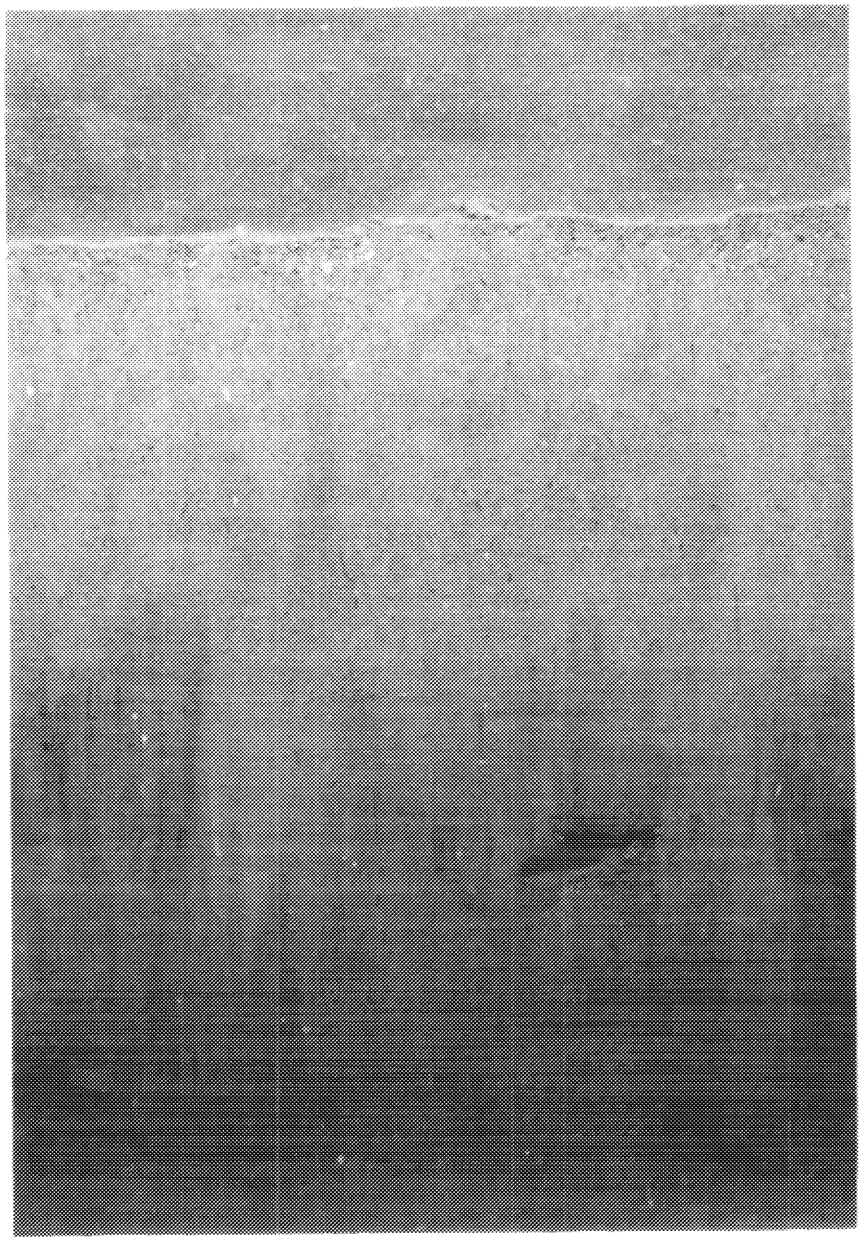


Figure 3-47b. REMOTS® image from station Center at CS-2. The image shows deep RPD depths and feeding voids, which are evidence of Stage III taxa. This mound apex station shows no evidence of physical disturbance. Scale = 1X.

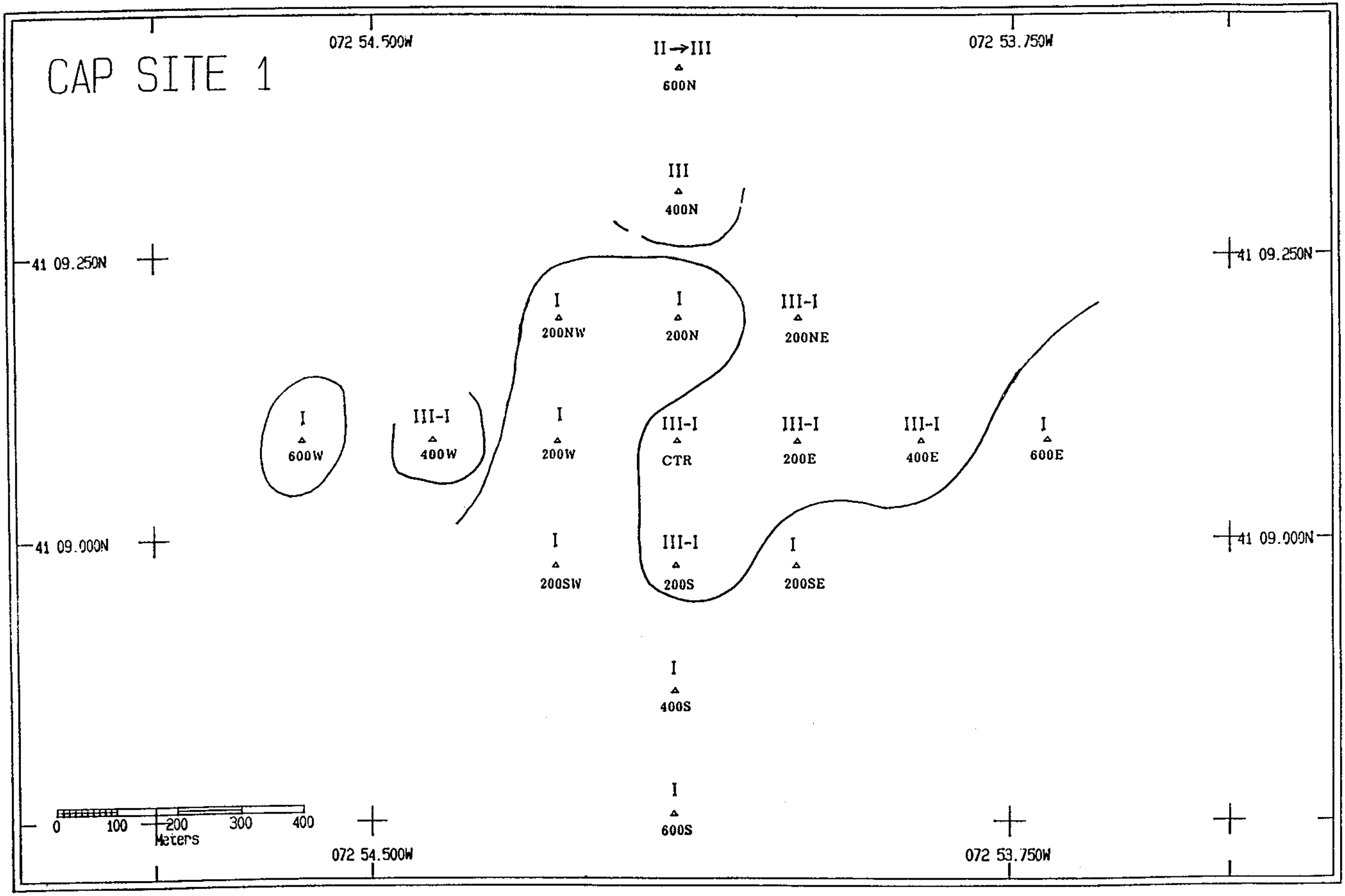


Figure 3-48a. The mapped distribution of successional stages for July 1986 at the CS-1 disposal mound. Solid and/or dashed lines delimit stations having only Stage I sere.

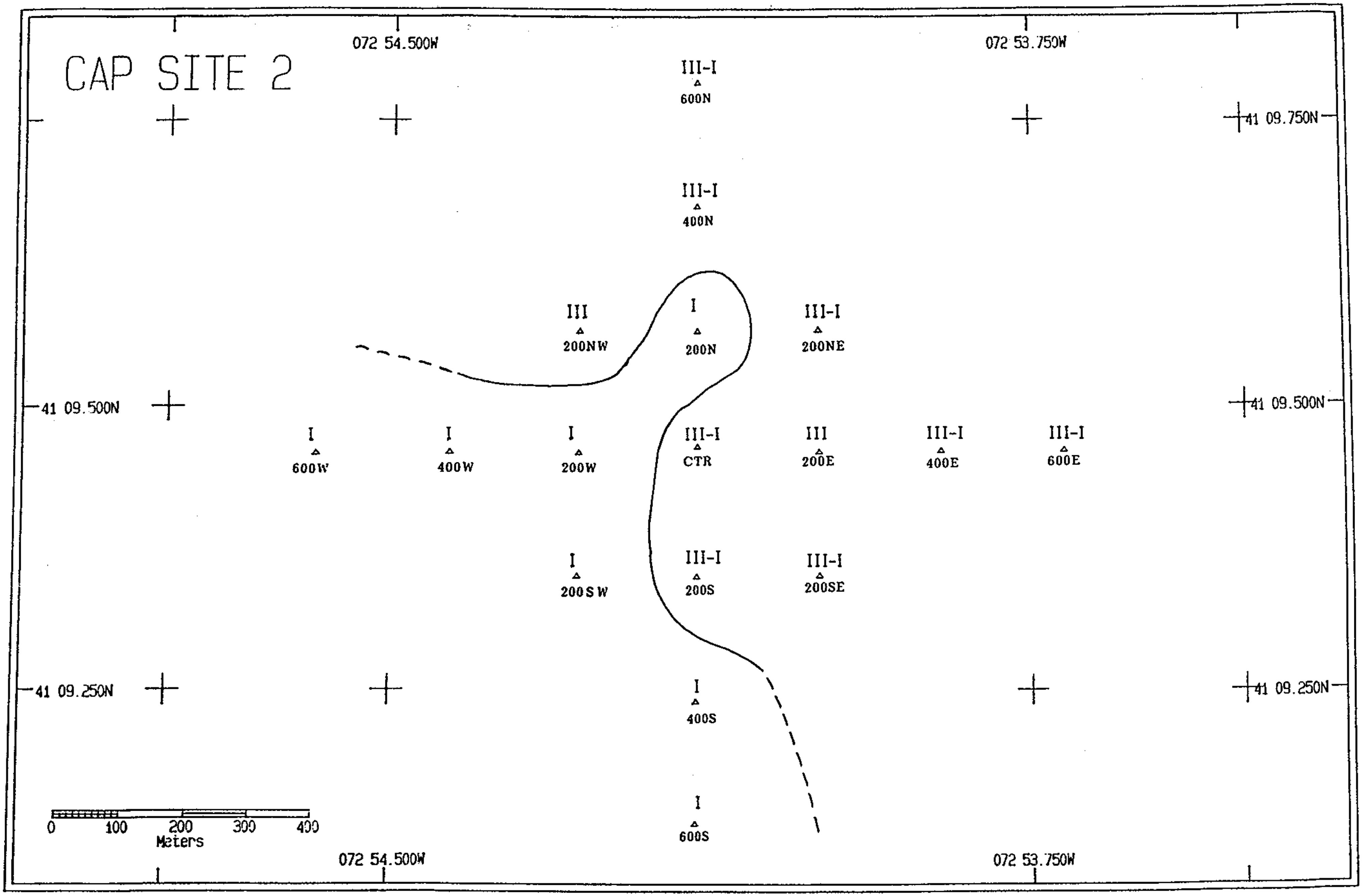


Figure 3-48b. The mapped distribution of successional stages for July 1986 at the CS-2 disposal mound. Solid and/or dashed lines delimit stations having only Stage I sere.

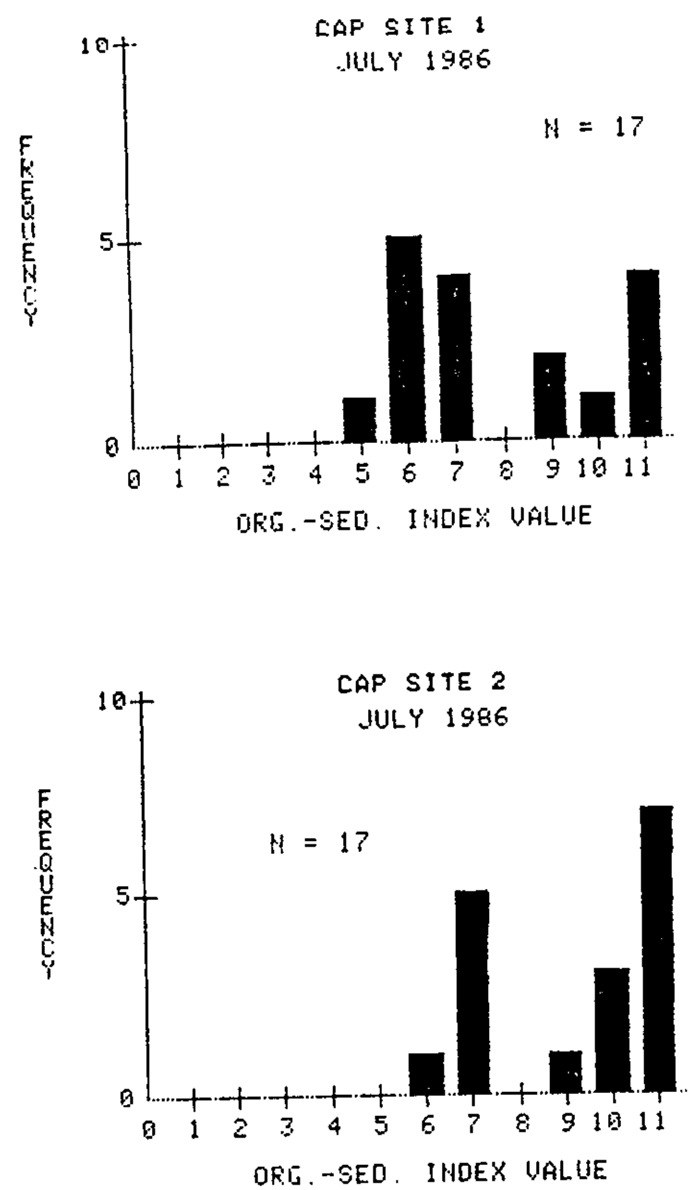


Figure 3-49. Frequency distributions of REMOTS® Organism-Sediment Indices (OSI's) at the CS-1 and CS-2 disposal mounds, July 1986.

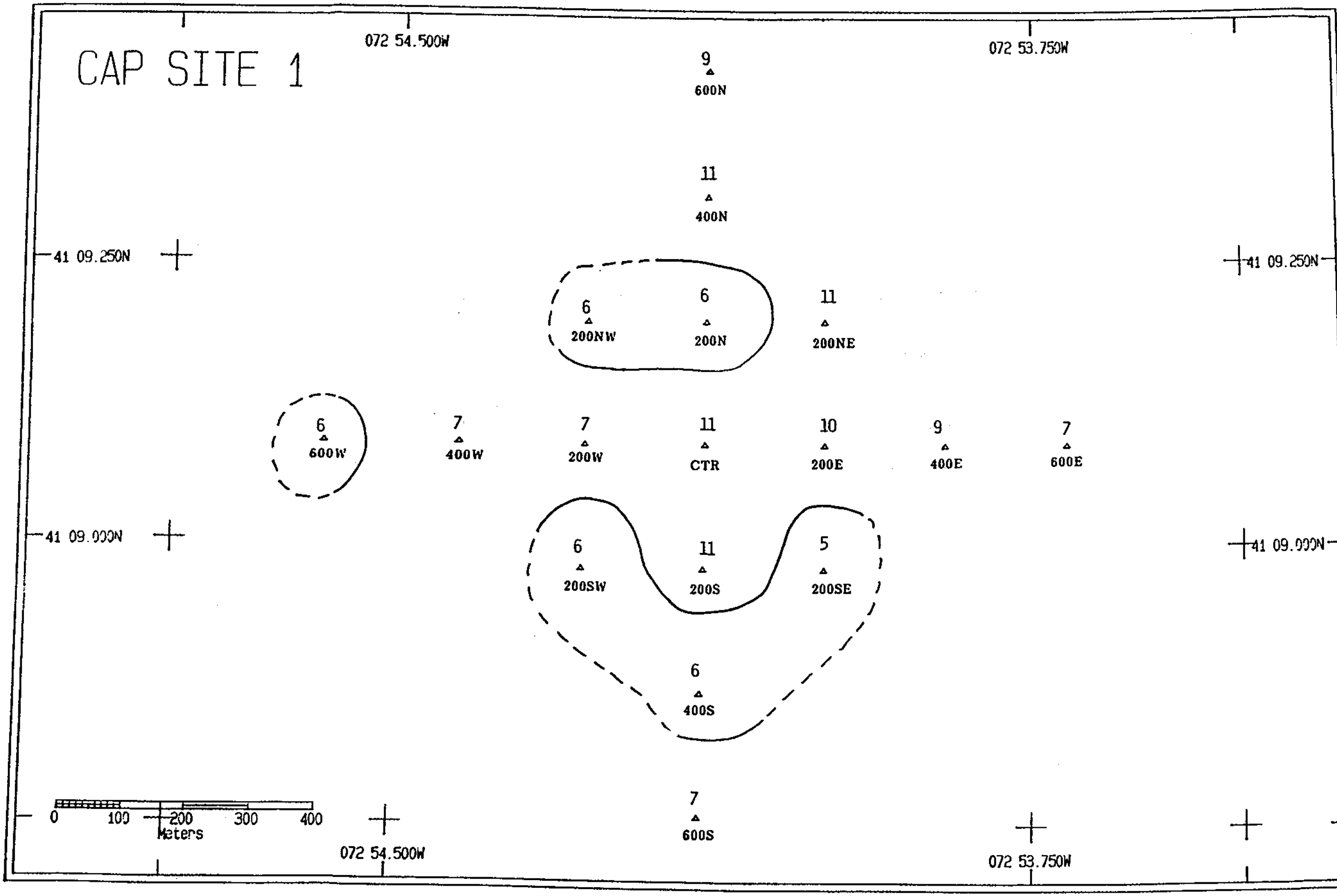


Figure 3-50a. The mapped distribution of REMOTS Organism-Sediment Indices (OSI's) at the CS-1 disposal mound, July 1986. Solid and/or dashed lines delimit stations having OSI values equal to or less than +6.

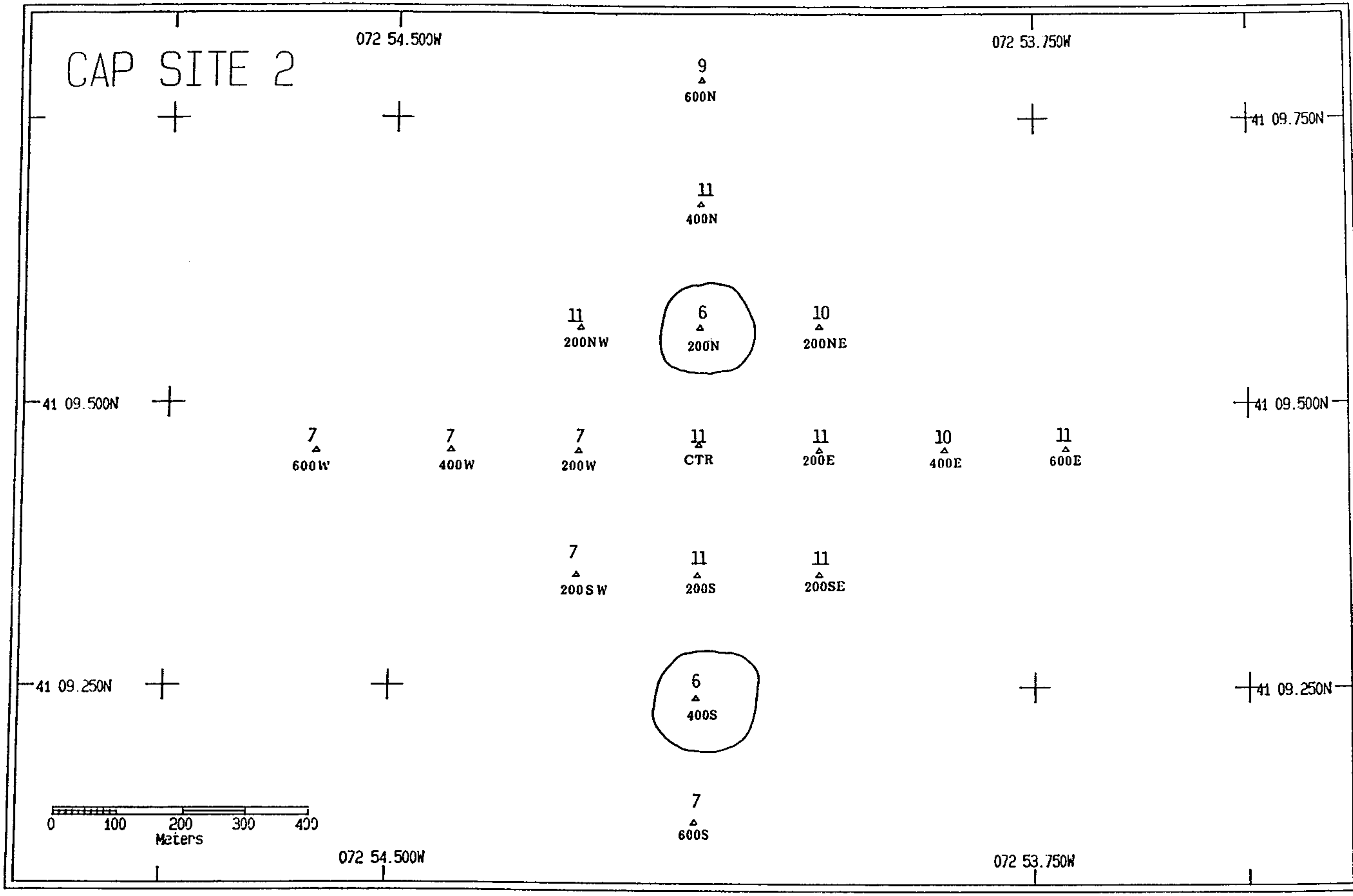


Figure 3-50b. The mapped distribution of REMOTS Organism-Sediment Indices (OSI's) at the CS-2 disposal mound, July 1986. Solid and/or dashed lines delimit stations having OSI values equal to or less than +6.

Figure 3-51. Benthic "process" map which indicates the distribution and thickness (cm) of apparent dredged material at the MQR disposal mound in July 1986. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

CH_4 = Methane gas present

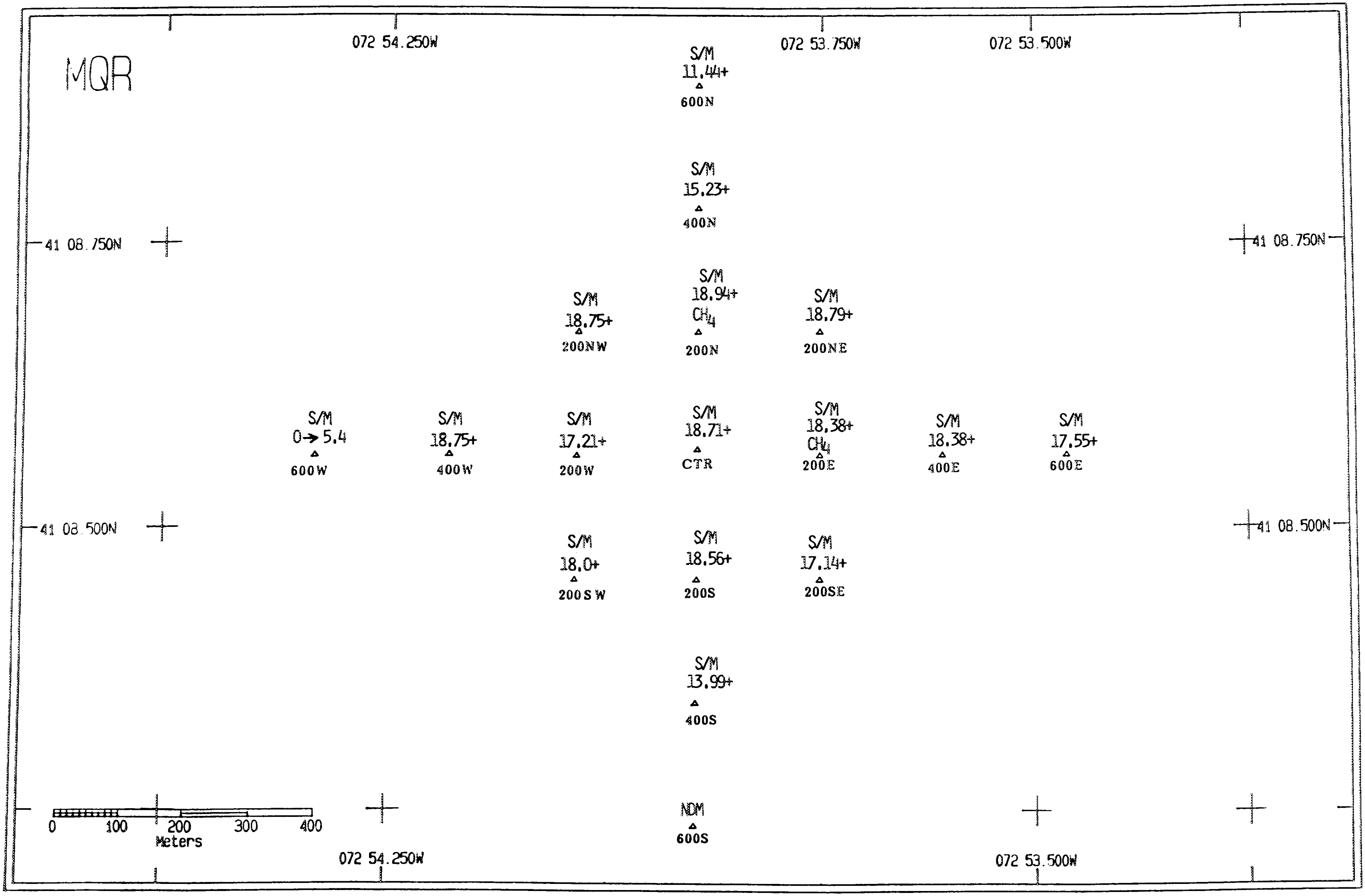

MQR
072 54.250W
072 53.750W
072 53.500W
41 08.750N
41 08.500N
S/M
11.44+
600N
S/M
15.23+
400N
S/M
18.75+
200NW
S/M
18.94+
CH_4
200N
S/M
18.79+
200NE
S/M
0→5.4
600W
S/M
18.75+
400W
S/M
17.21+
200W
S/M
18.71+
CTR
S/M
18.38+
CH_4
200E
S/M
18.38+
400E
S/M
17.55+
600E
S/M
18.0+
200SW
S/M
18.56+
200S
S/M
17.14+
200SE
S/M
13.99+
400S
NDM
600S
0 100 200 300 400
Meters
072 54.250W
072 53.500W

Figure 3-51.

Figure 3-52a. REMOTS® image from station 200E showing methane gas bubbles (arrows) in the sediment. Scale = 1X.

Figure 3-52b. REMOTS® image from station 200N showing methane gas bubbles (arrows) in the sediment. Scale = 1X.

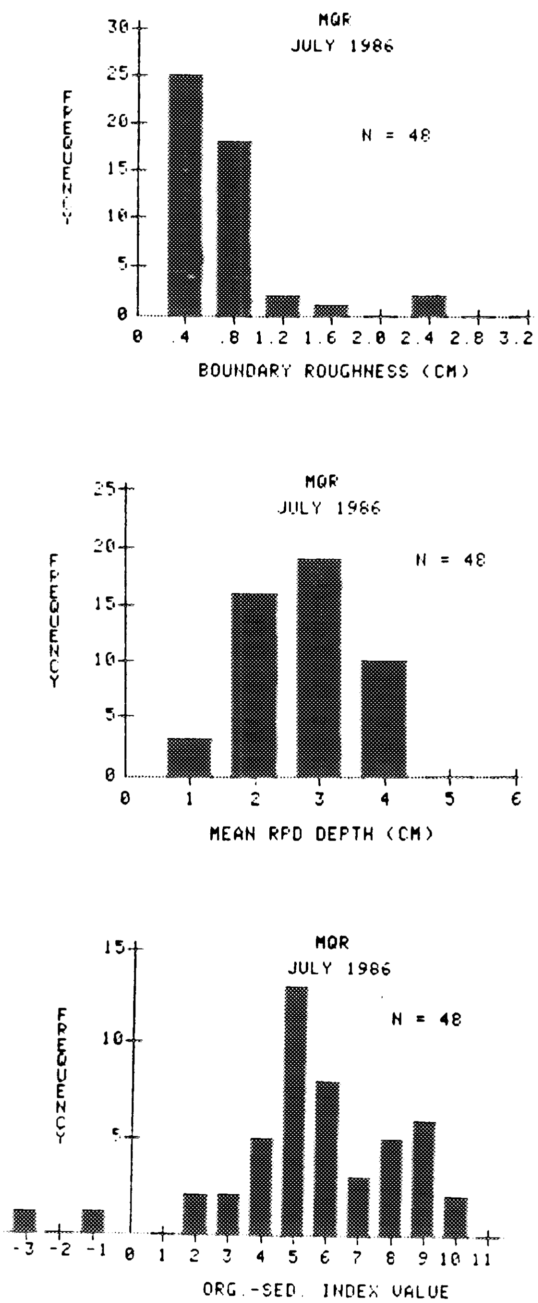


Figure 3-53. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the MQR disposal mound, July 1986.

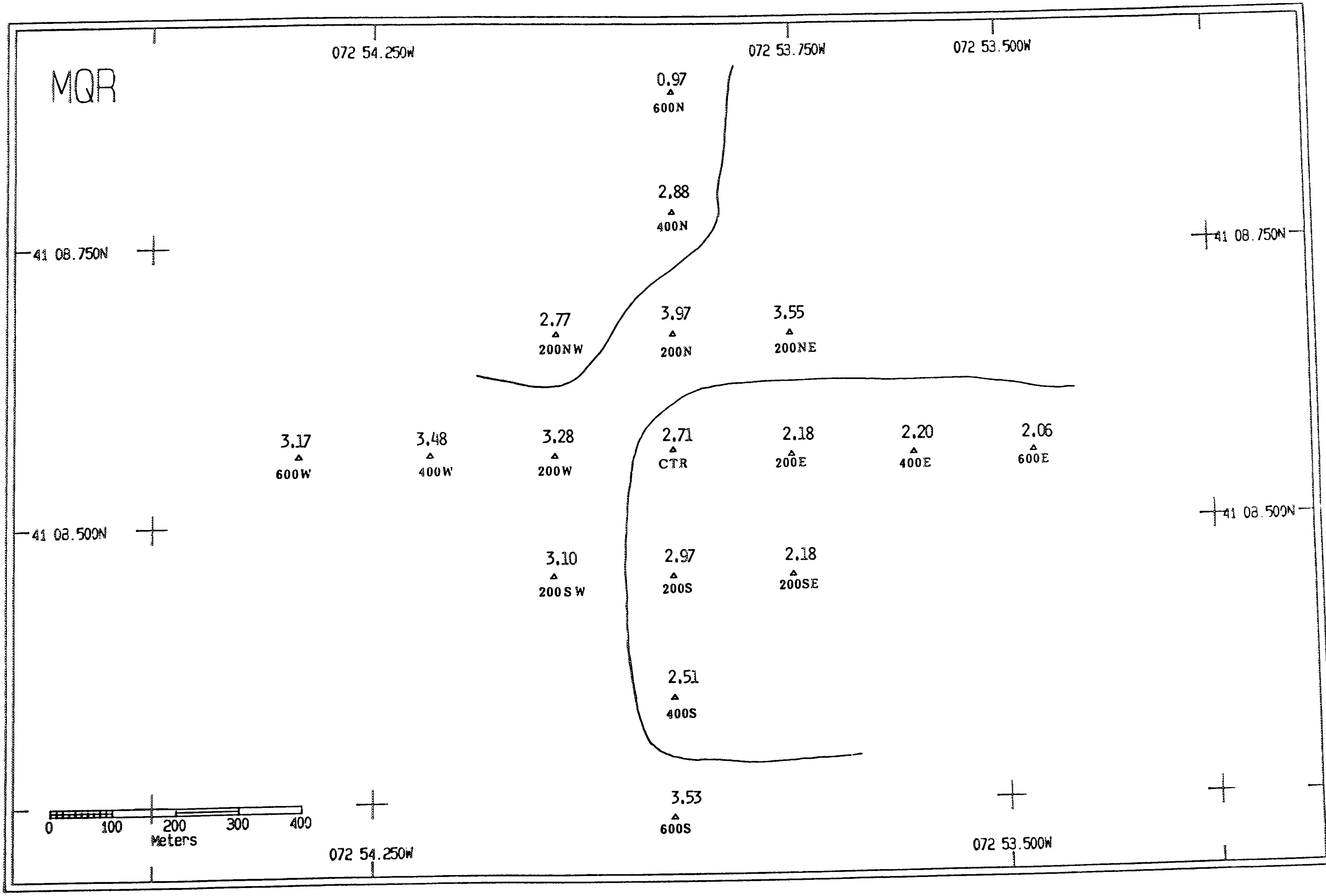


Figure 3-54. The mapped distribution of mean apparent RPD depths (cm) at the MQR disposal mound, July 1986. Contours delimit areas having mean RPD depths less than 3 cm.

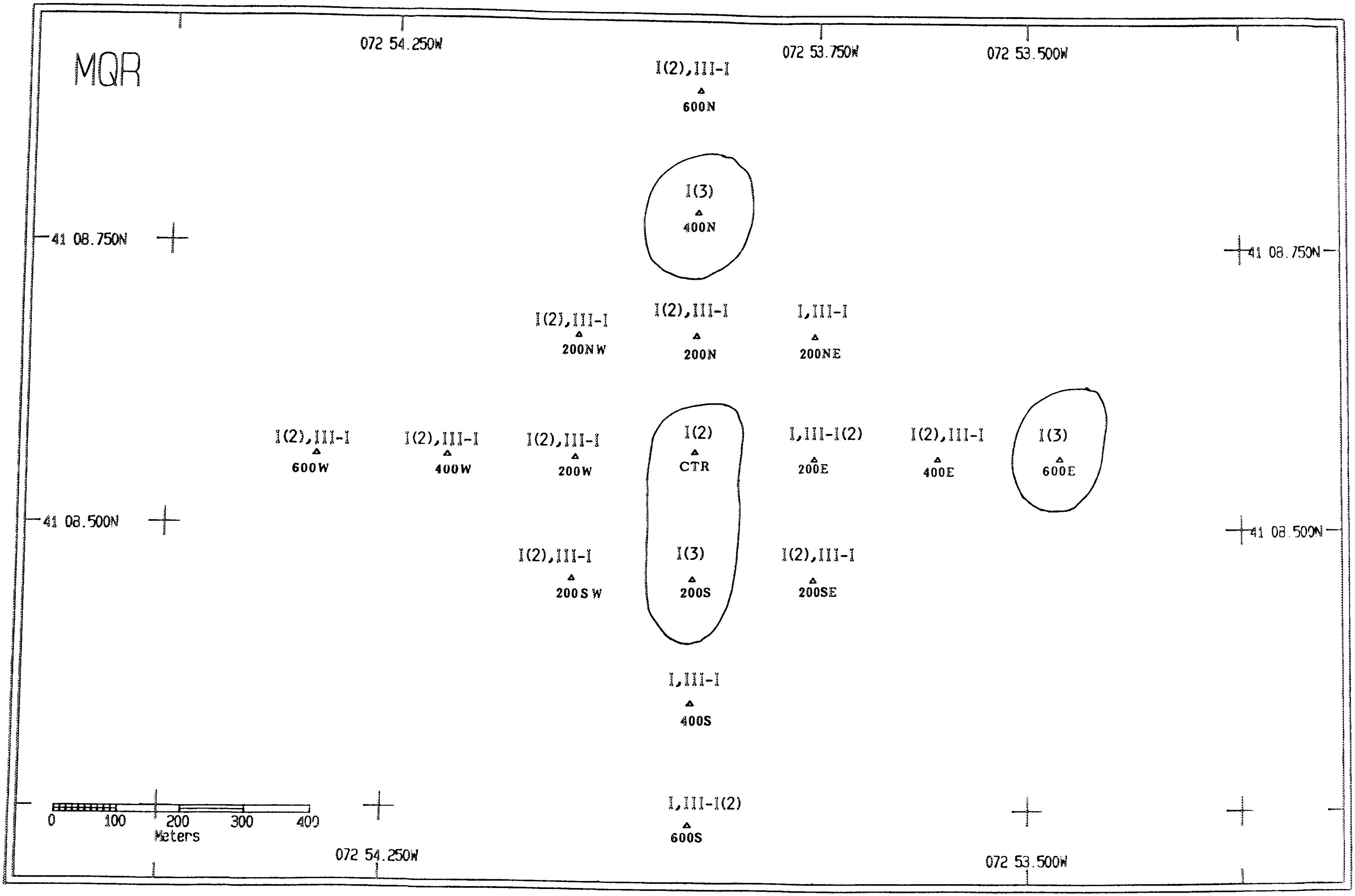


Figure 3-55. The mapped distribution of infaunal successional stages at the MQR disposal mound, July 1986. The number of replicates exhibiting a particular successional stage is indicated in parentheses where applicable. Contours indicate Stage I sere.

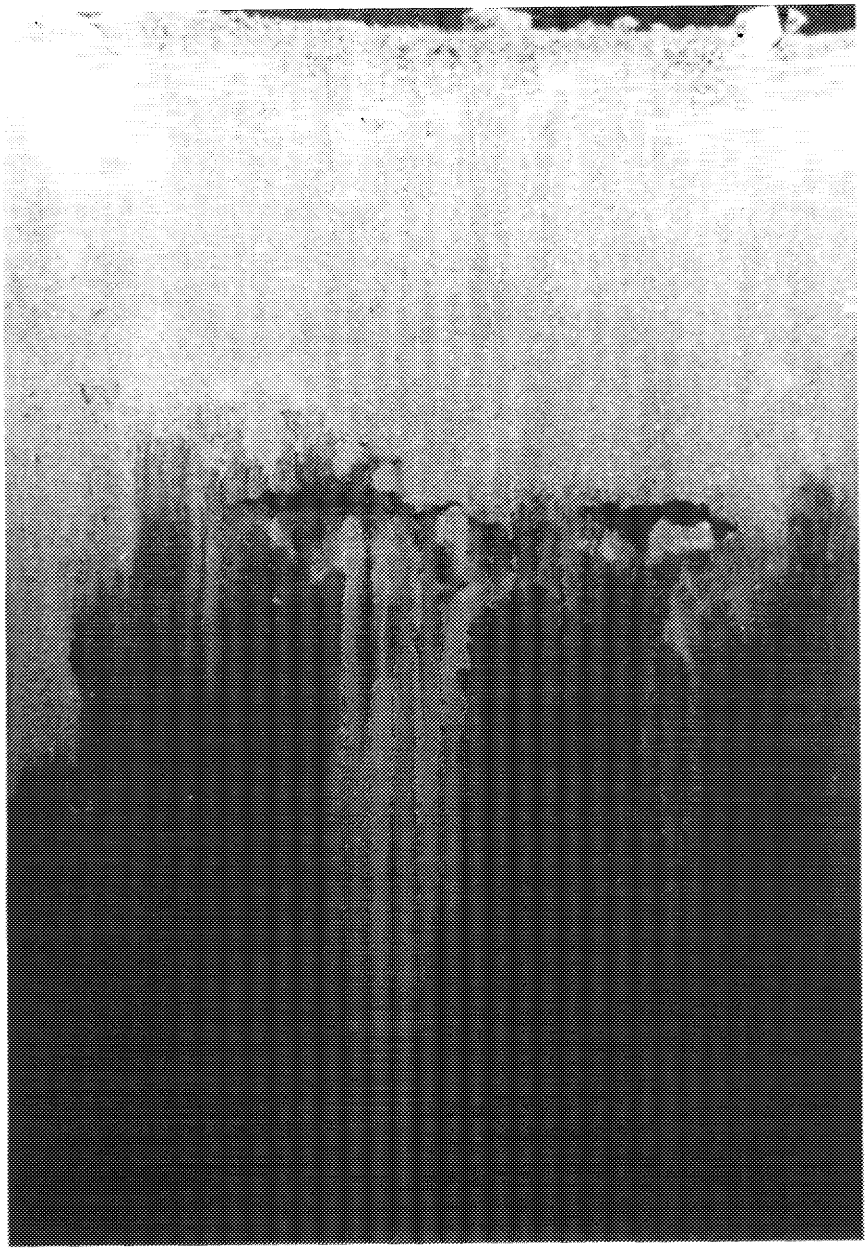


Figure 3-56. REMOTS® image from station 200N showing well-developed feeding voids (evidence of Stage III taxa) near the apparent RPD boundary. Scale = 1X.

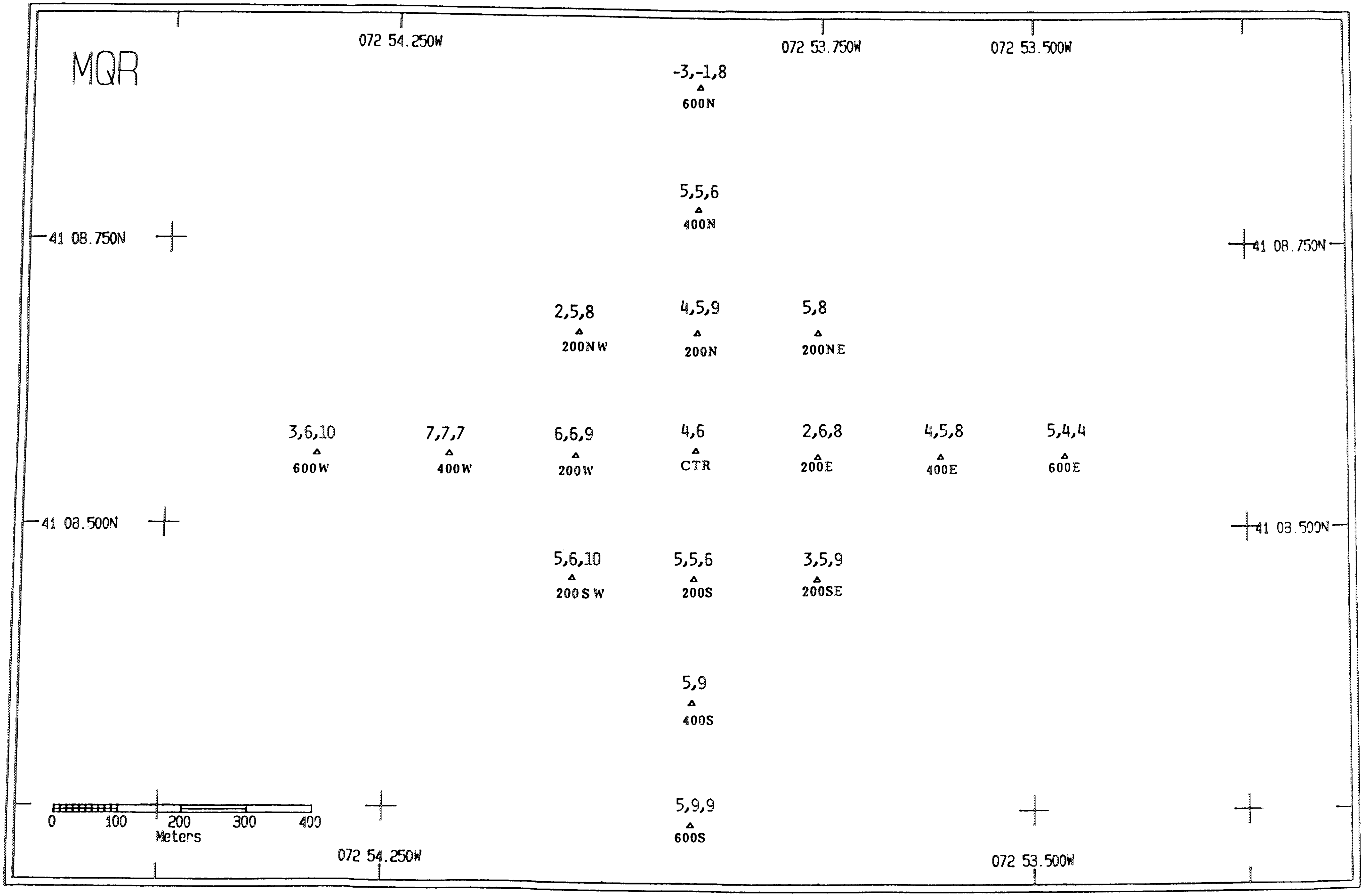


Figure 3-57. The mapped distribution of REMOTS Organism-Sediment Indices (OSI's) for all replicates at the MQR disposal mound, July 1986.

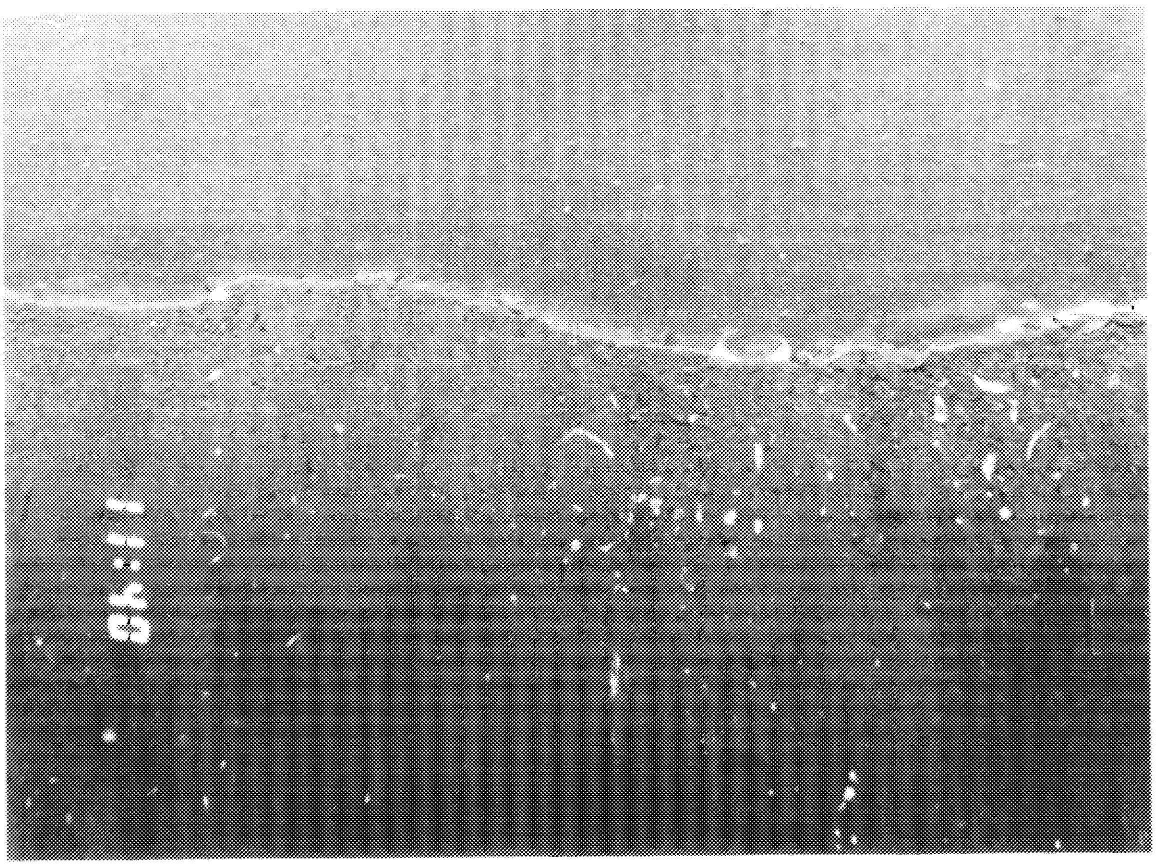


Figure 3-58. REMOTS® image from station 600N showing a shallow RPD, possibly attributed to local surface erosion at this station. Scale = 1X.

Figure 3-59. Benthic "process" map which indicates the distribution and thickness (cm) of apparent dredged material at the Norwalk disposal mound in July 1986. Hatched area delimits the extent of apparent dredged material. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

SHELL = Shell lag deposit

RS = Reduced sediment near the sediment-water interface

CH_4 = Methane gas present

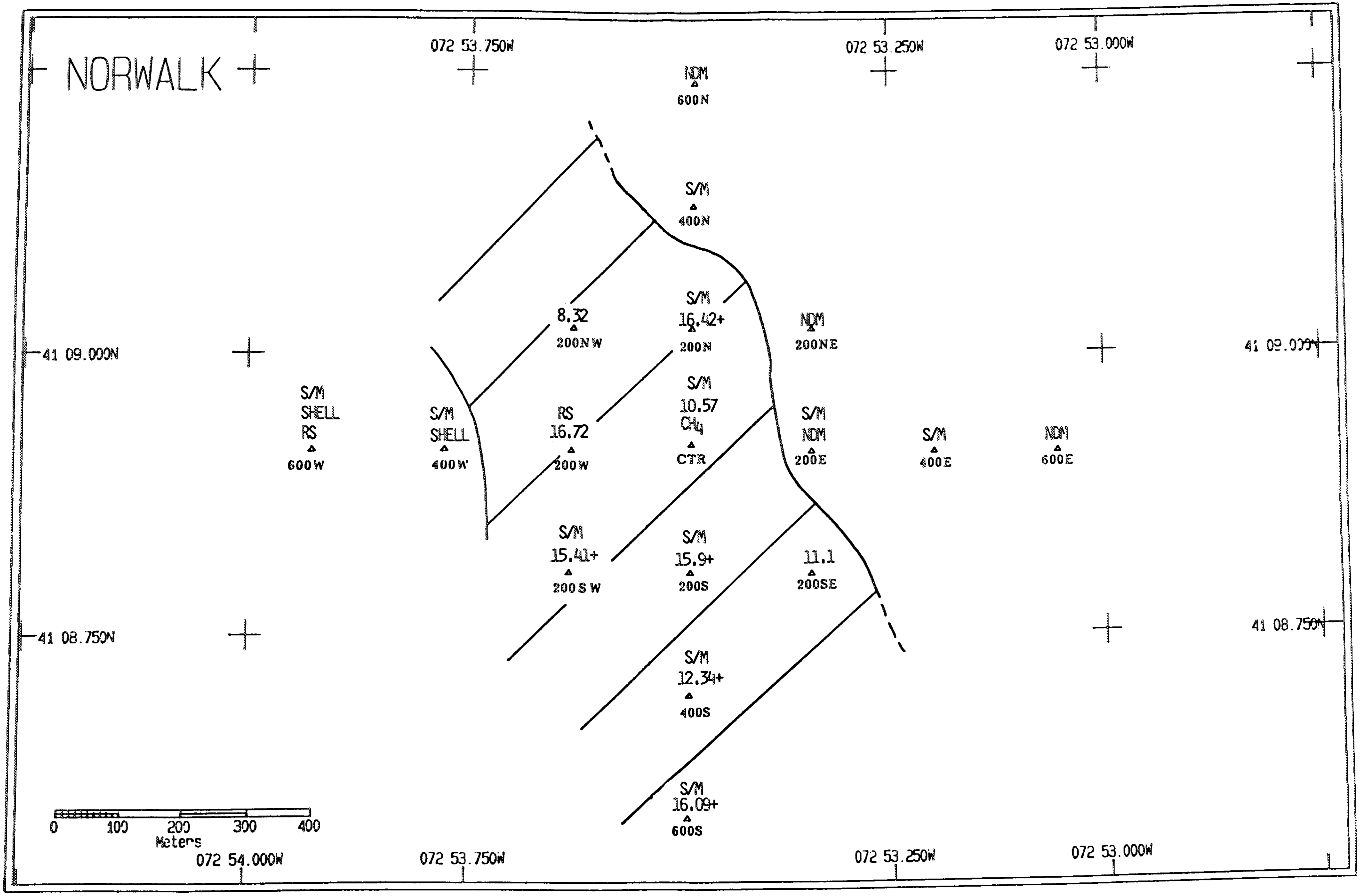

NORWALK
072 53.750W
072 53.250W
072 53.000W
NDM
600N
S/M
400N
S/M
16.42+
200N
8.32
200NW
NDM
200NE
41 09.000N
41 09.000N
S/M
SHELL
RS
600W
S/M
SHELL
400W
RS
16.72
200W
S/M
10.57
CH_4
CTR
S/M
NDM
200E
S/M
400E
NDM
600E
S/M
15.41+
200SW
S/M
15.9+
200S
11.1
200SE
41 08.750N
41 08.750N
S/M
12.34+
400S
S/M
16.09+
600S
0
100
200
300
400
Meters
072 54.000W
072 53.750W
072 53.250W
072 53.000W

Figure 3-59.

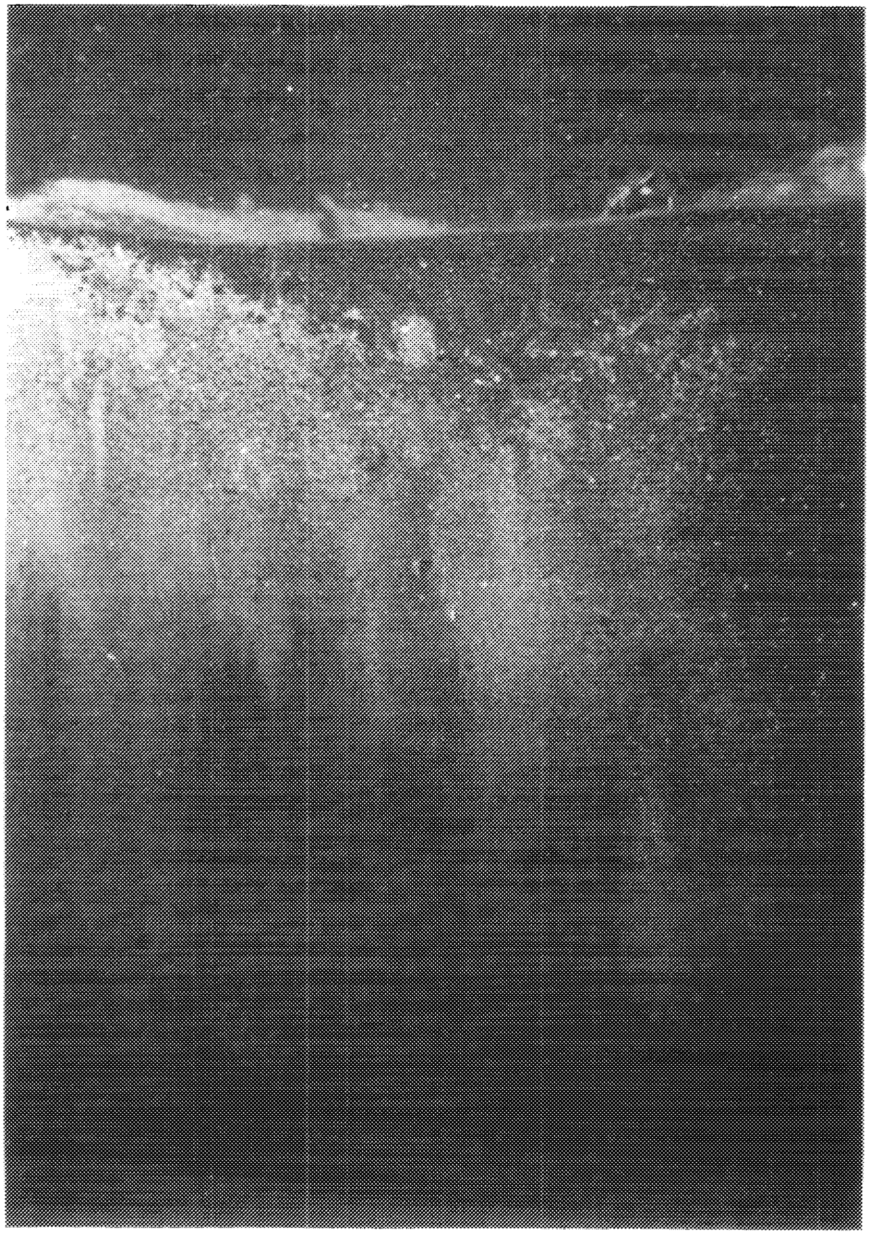


Figure 3-60. REMOTS® image from station 200W showing low reflectance sediment at the surface. This reduced sediment was probably derived from excavation of a nearby burrow. Scale = 1X.

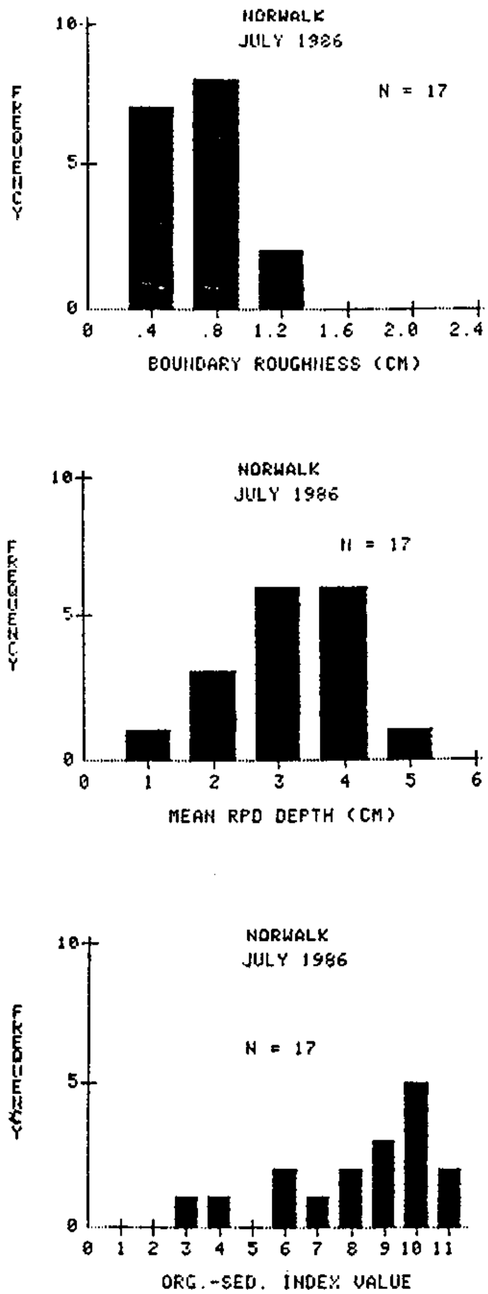


Figure 3-61. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the Norwalk disposal mound, July 1986.

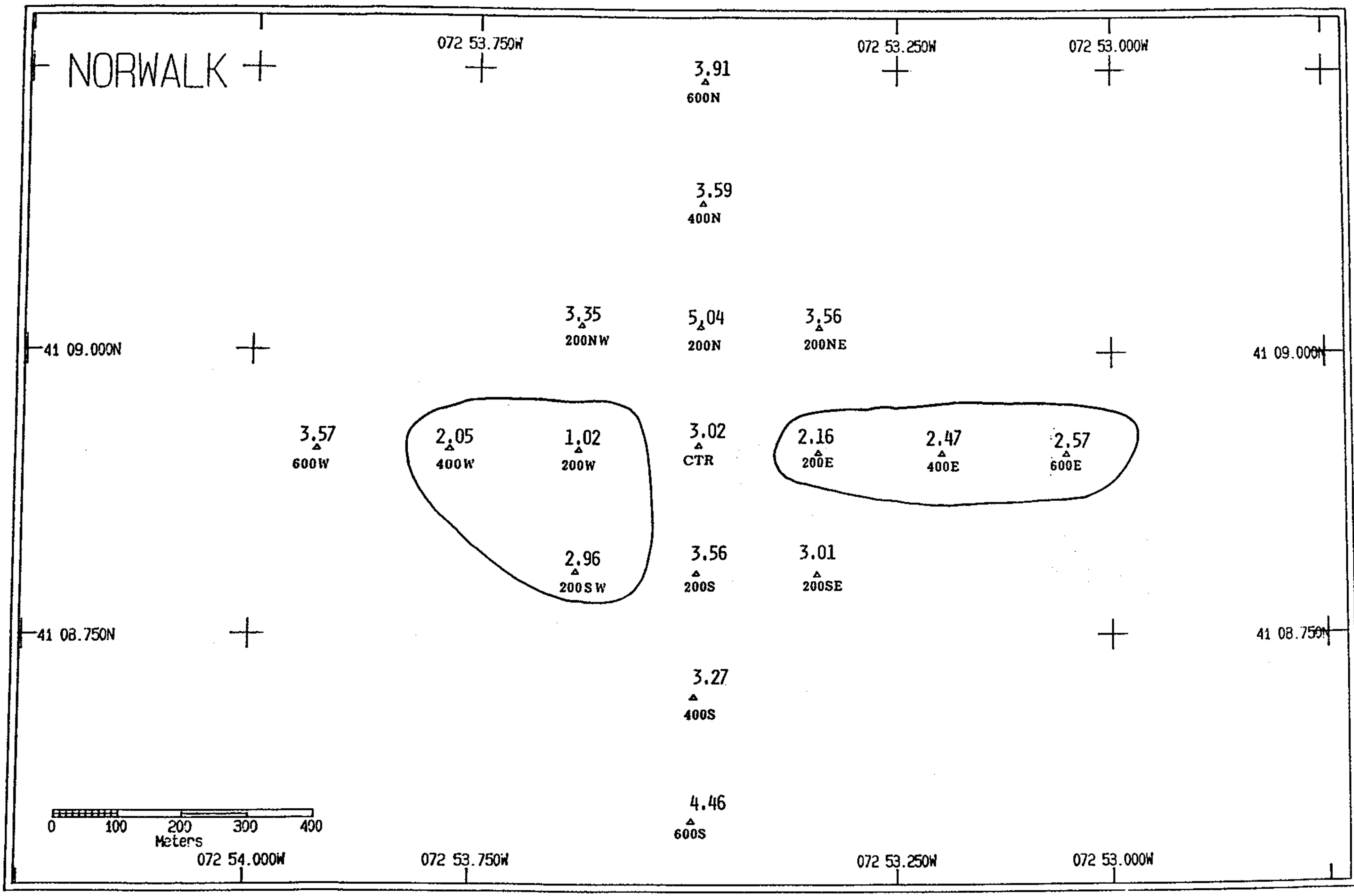


Figure 3-62. The mapped distribution of mean apparent RPD depths (cm) at the Norwalk disposal mound, July 1986. Solid lines delimit stations having RPD depths less than or equal to 3 cm.

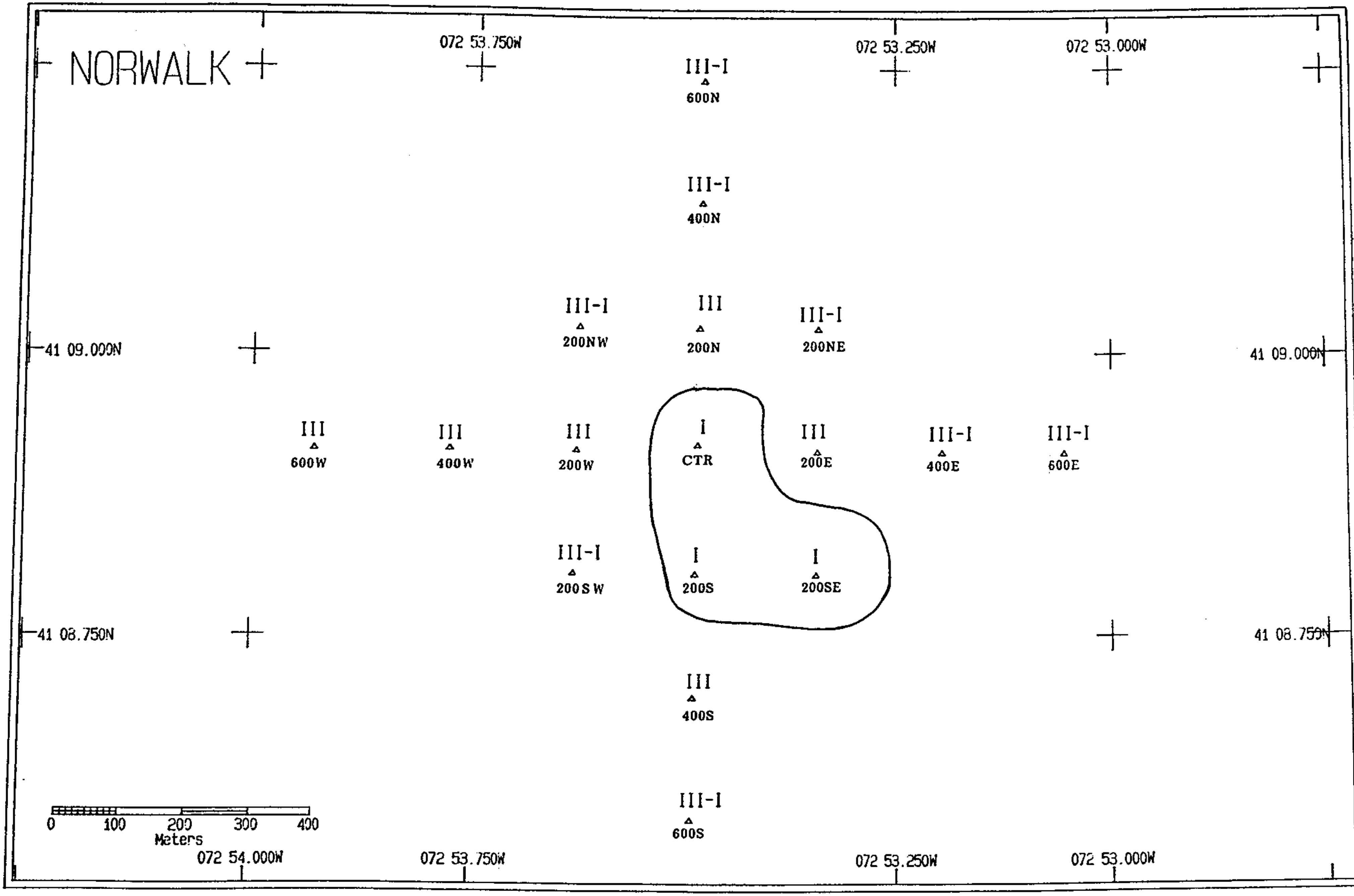


Figure 3-63. The mapped distribution of infaunal successional stages at the Norwalk disposal mound, July 1986. Solid lines delimit stations having only a Stage I successional stage.

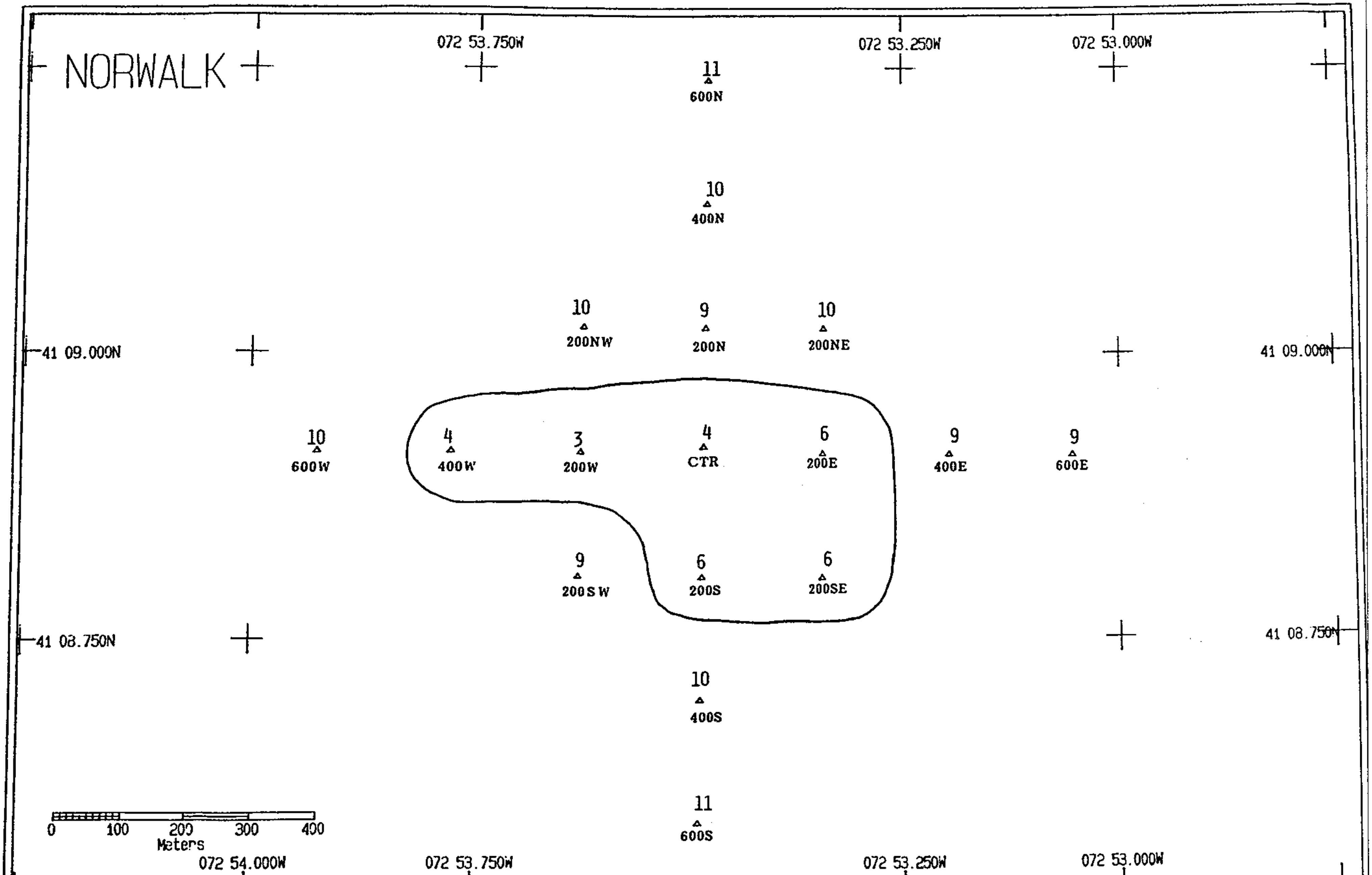


Figure 3-64. The mapped distribution of REMOTS Organism-Sediment Indices (OSI's) at the Norwalk disposal mound, July 1986. Solid lines delimit stations having OSI values of +6 or less.

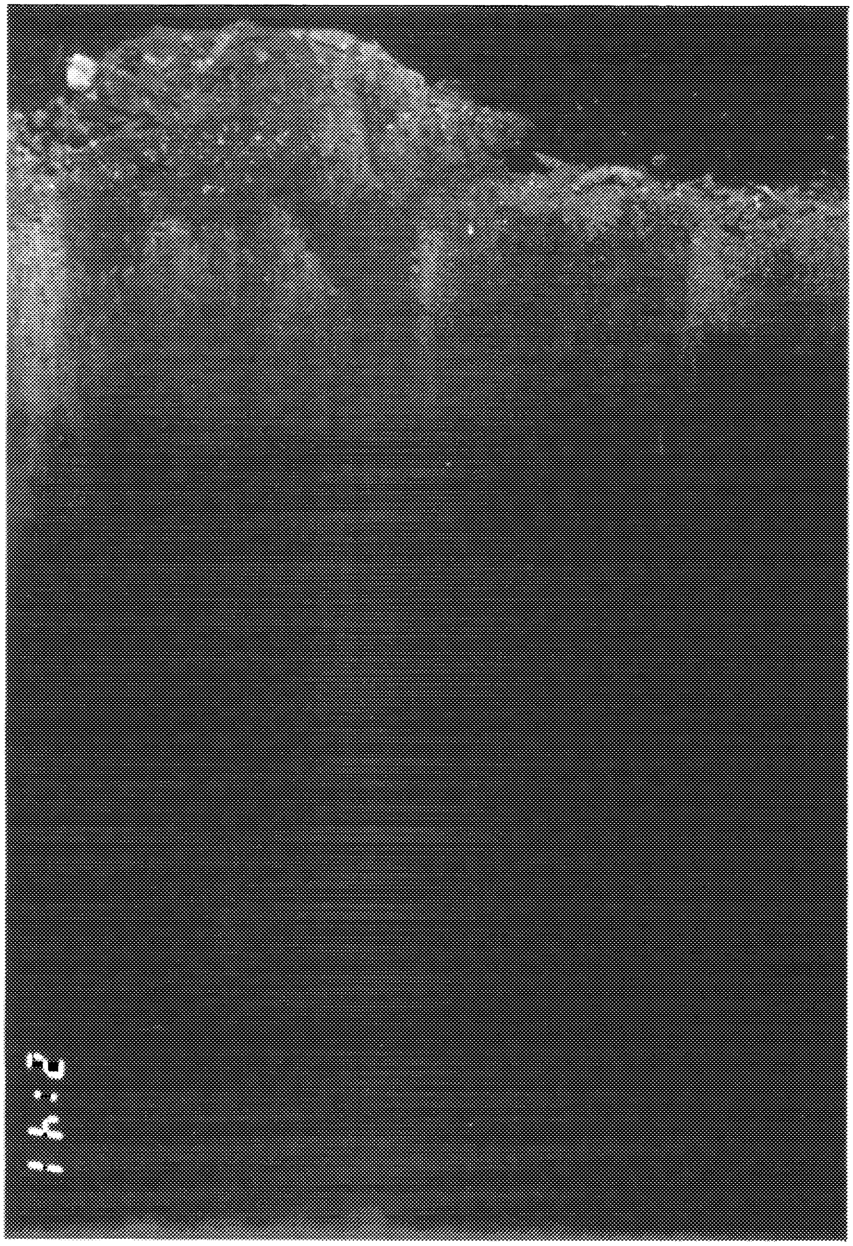


Figure 3-65. REMOTS® image from station Center at NH-74 showing a very thin surface sand layer and shallow RPD depth, suggesting recent erosion of aerated surface sediments which once comprised the sand cap at this mound. Scale = 1X.

Figure 3-66. Benthic "process" map which indicates the distribution and thickness (cm) of apparent dredged material at the NH-74 disposal mound in July 1986. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

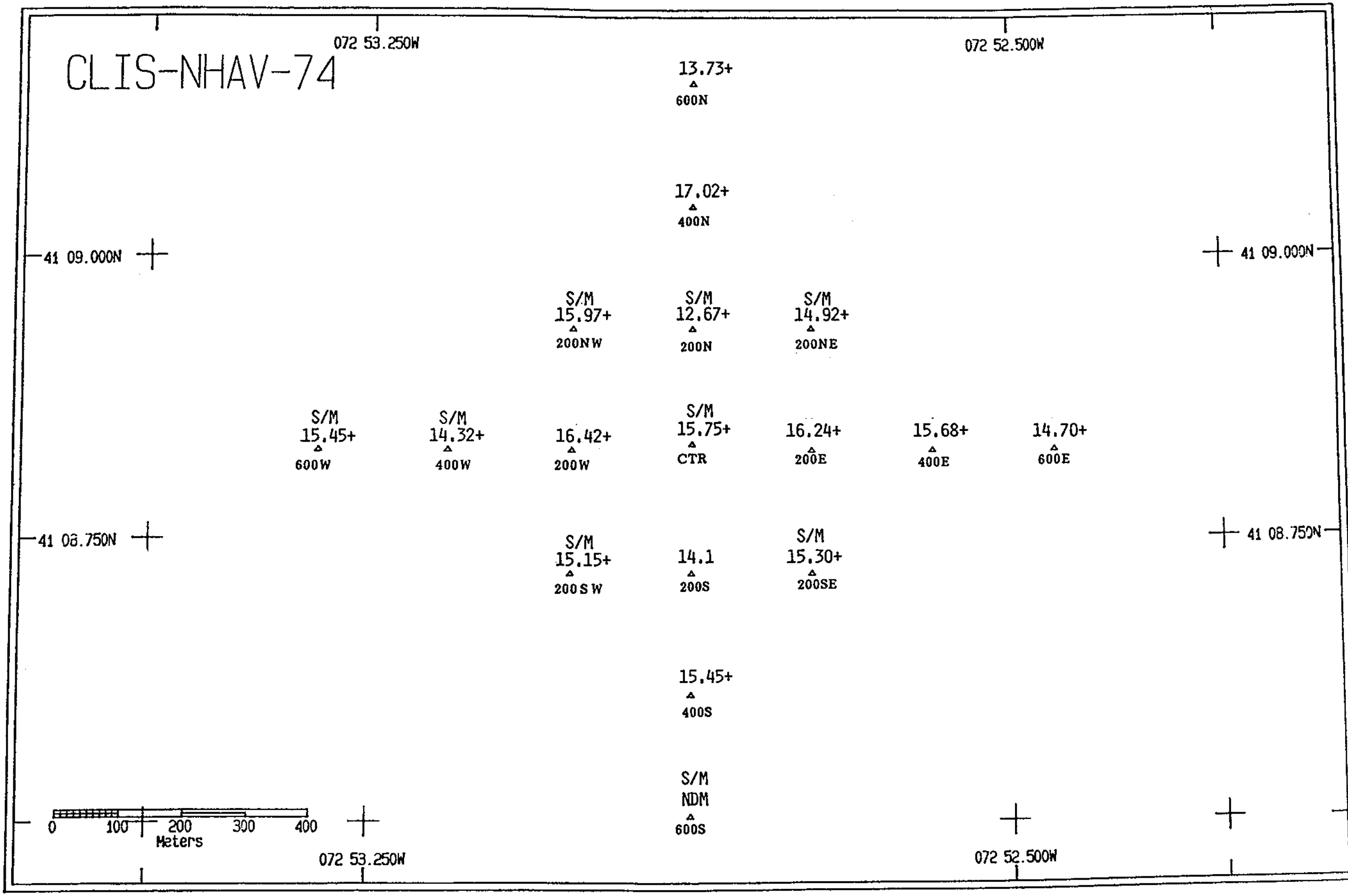

CLIS-NHAV-74
072 53.250W
072 52.500W
41 09.000N
41 08.750N
13.73+
600N
17.02+
400N
S/M
15.97+
200NW
S/M
12.67+
200N
S/M
14.92+
200NE
S/M
15.45+
600W
S/M
14.32+
400W
16.42+
200W
S/M
15.75+
CTR
16.24+
200E
15.68+
400E
14.70+
600E
S/M
15.15+
200SW
14.1
200S
S/M
15.30+
200SE
15.45+
400S
S/M
NDM
600S
0 100 200 300 400
Meters

Figure 3-66.

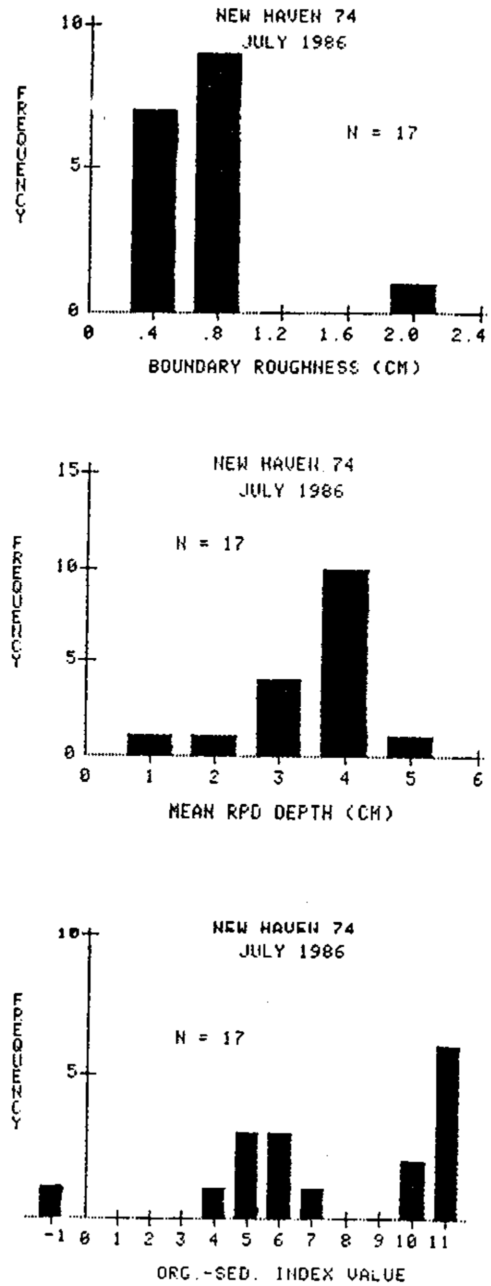


Figure 3-67. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the NH-74 disposal mound, July 1986.

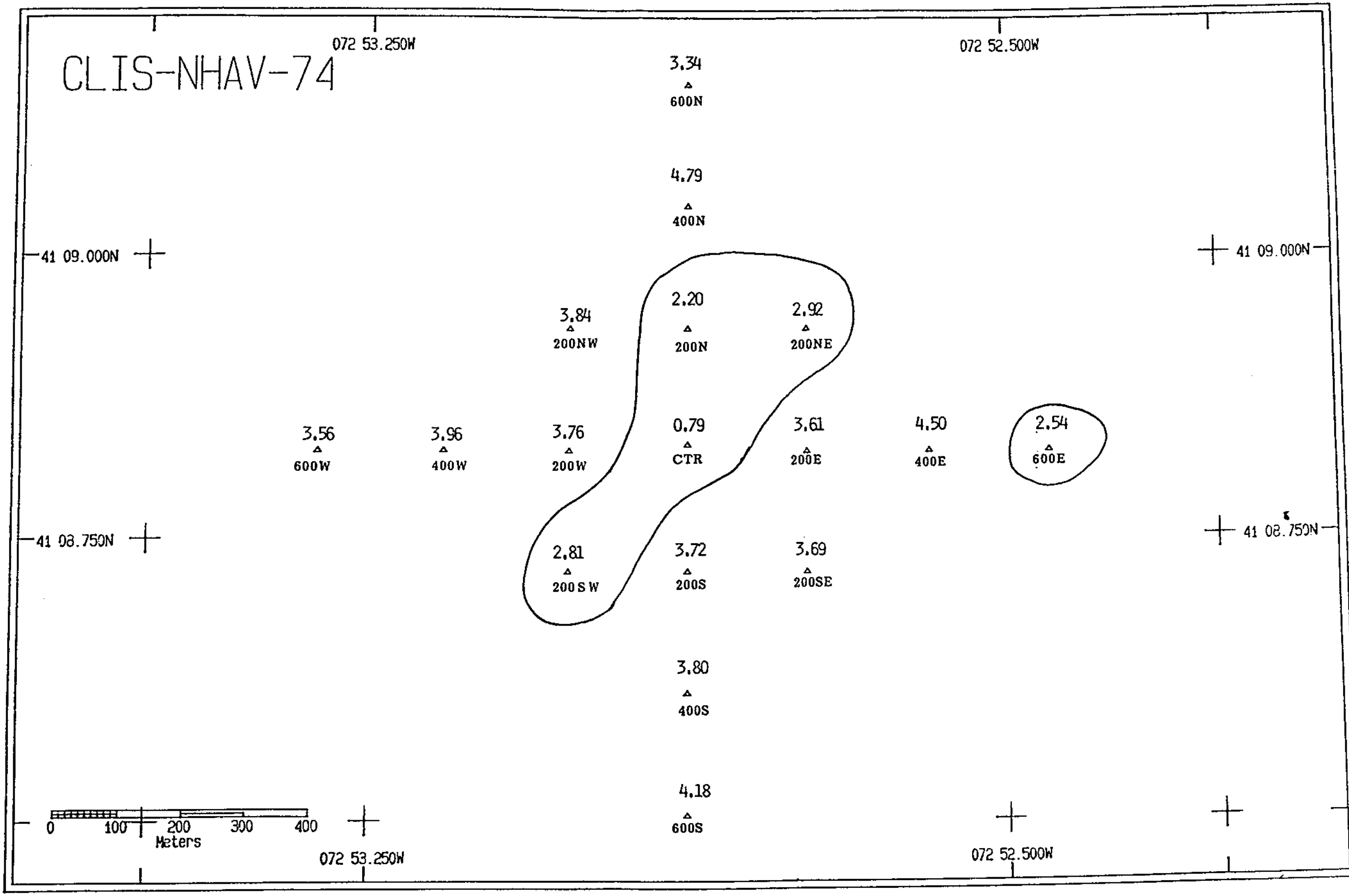


Figure 3-68. The mapped distribution of mean apparent RPD depths at the NH-74 disposal mound, July 1986. Solid lines delimit stations having RPD depths less than or equal to 3 cm.

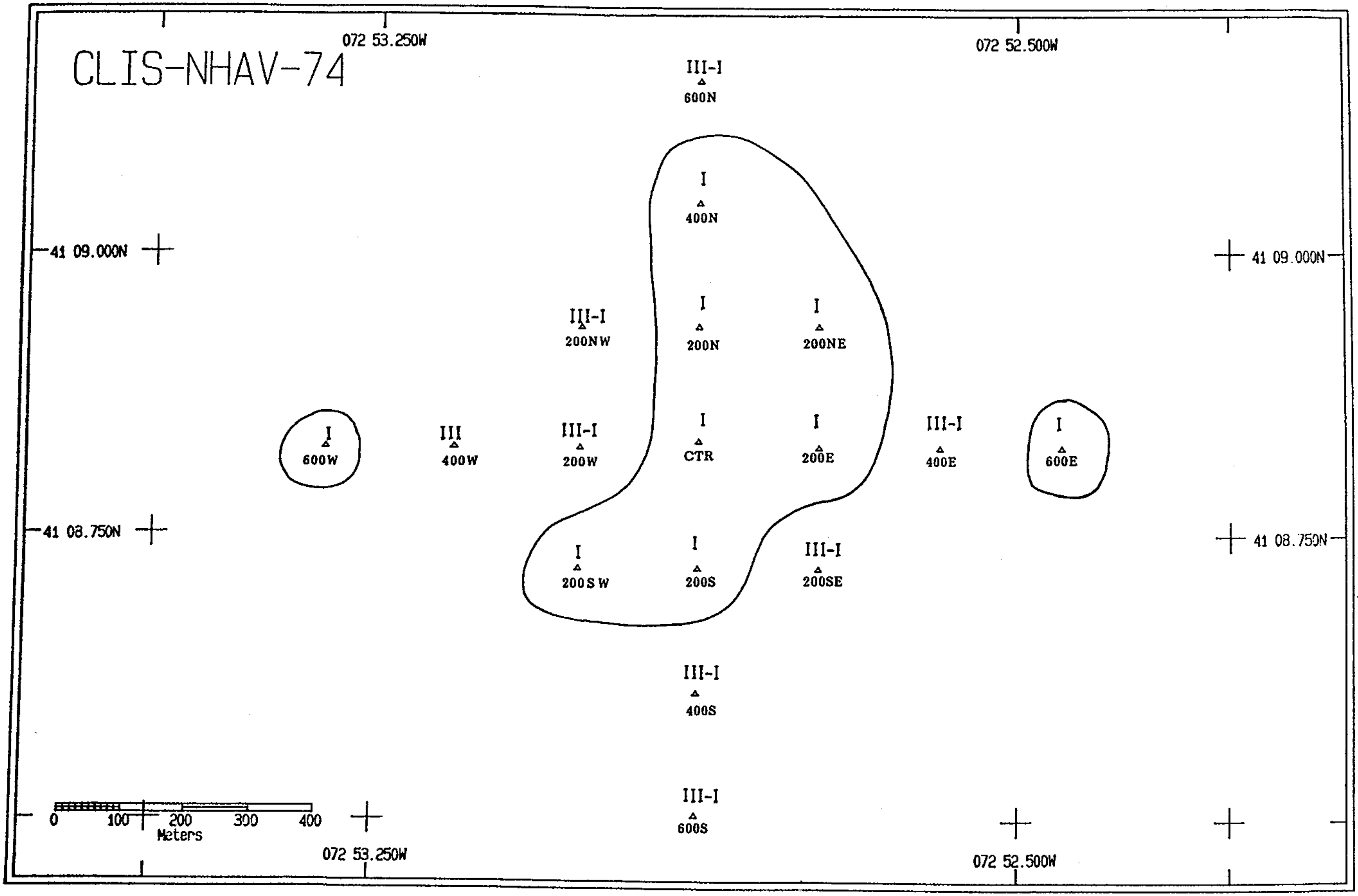


Figure 3-69. The mapped distribution of infaunal successional stages at the NH-74 disposal mound, July 1986. Solid lines delimit stations having only a Stage I successional stage.

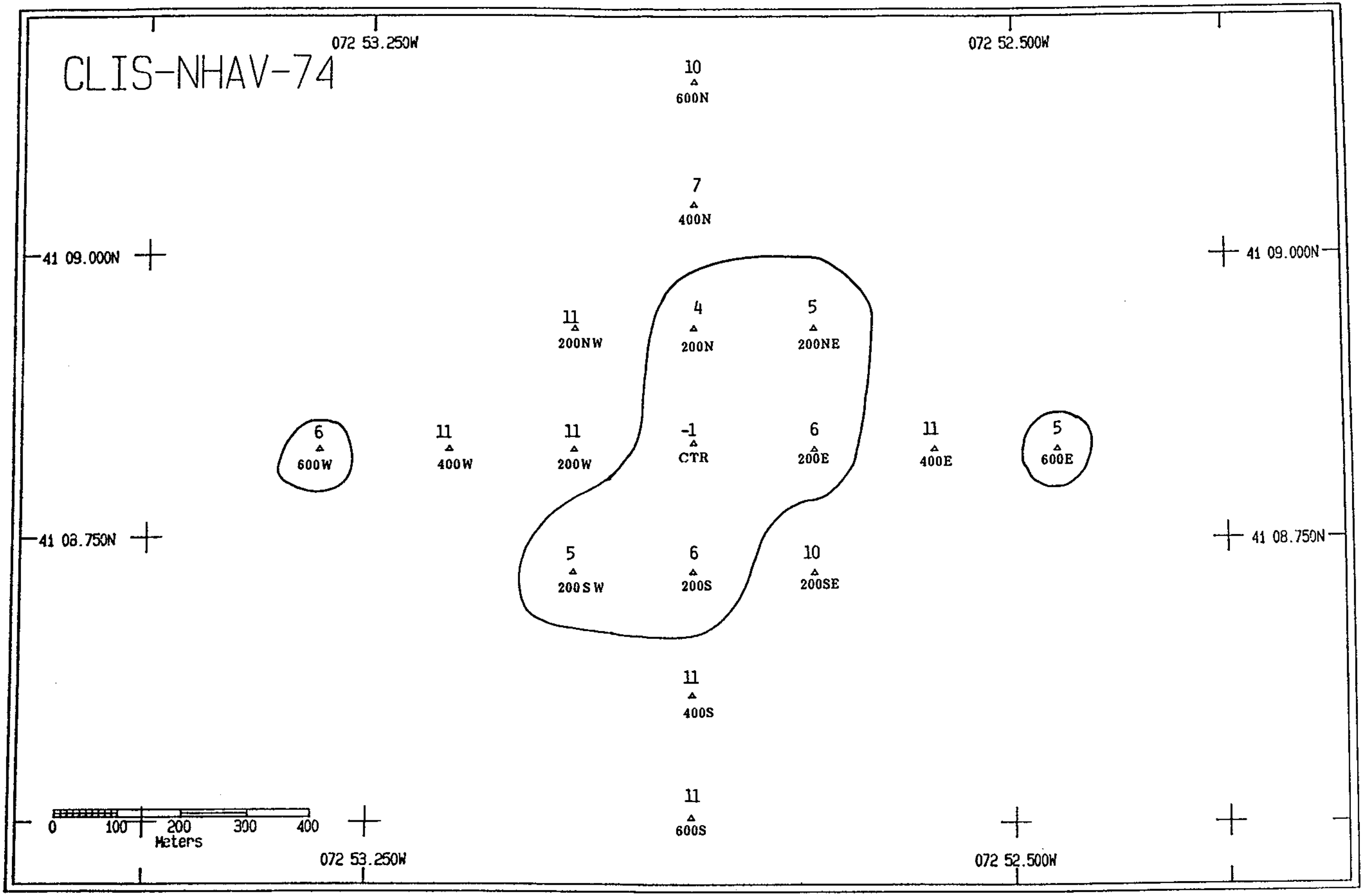


Figure 3-70. The mapped distribution of REMOTS Organism-Sediment Indices (OSI's) at the NH-74 disposal mound, July 1986. Solid lines delimit stations having OSI values of +6 or less.

Figure 3-71. Benthic "process" map which indicates the distribution and thickness (cm) of apparent dredged material at the NH-83 disposal mound in July 1986. Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy

RS = Reduced sediment near the sediment-water interface

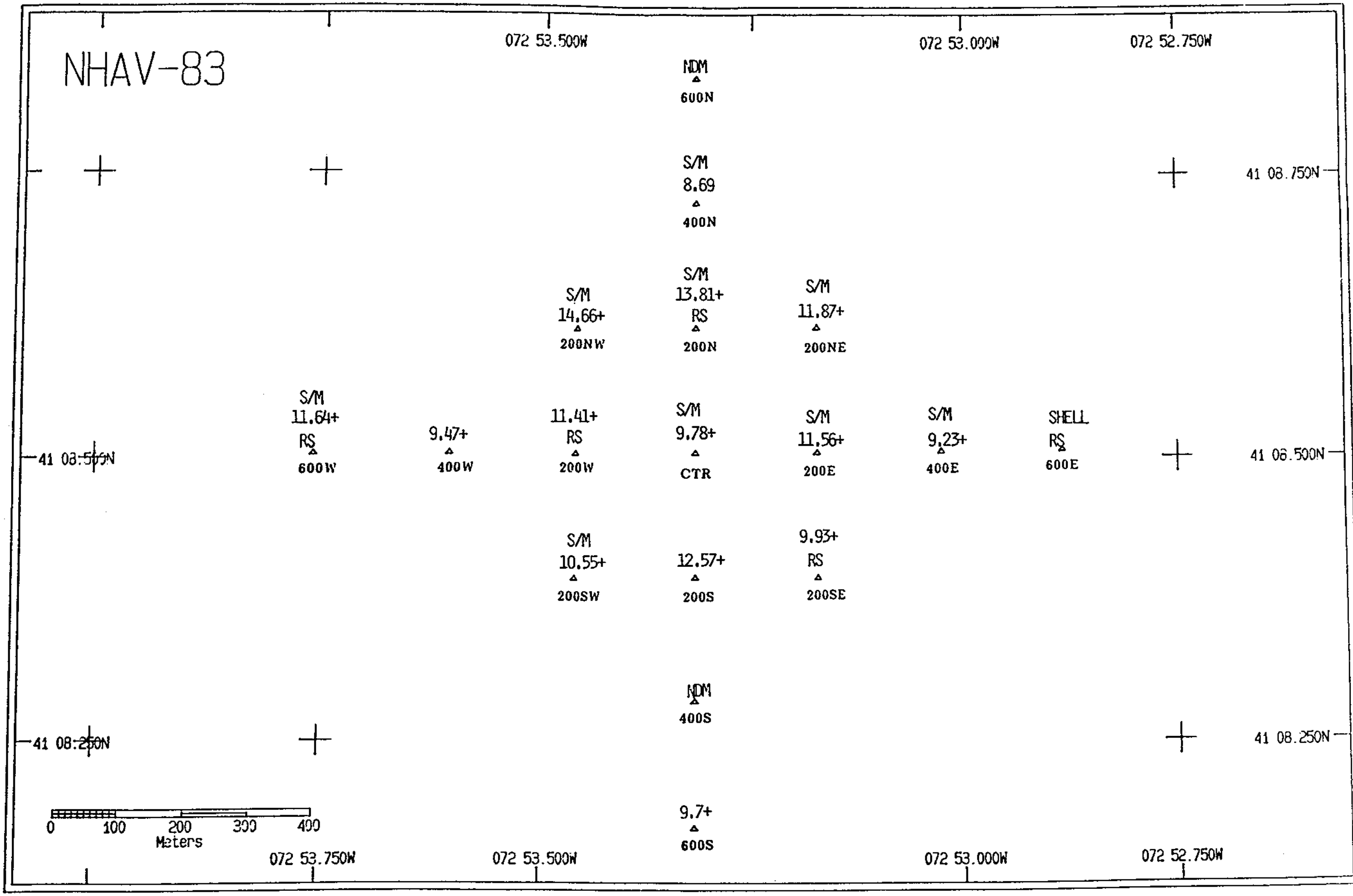

NHAV-83
072 53.500W
072 53.000W
072 52.750W
NDM
600N
S/M
8.69
400N
41 08.750N
S/M
14.66+
200NW
S/M
13.81+
RS
200N
S/M
11.87+
200NE
S/M
11.64+
RS
600W
9.47+
400W
11.41+
RS
200W
S/M
9.78+
CTR
S/M
11.56+
200E
S/M
9.23+
400E
SHELL
RS
600E
41 08.500N
S/M
10.55+
200SW
12.57+
200S
9.93+
RS
200SE
NDM
400S
41 08.250N
9.7+
600S
0
100
200
300
400
Meters
072 53.750W
072 53.500W
072 53.000W
072 52.750W

Figure 3-71.

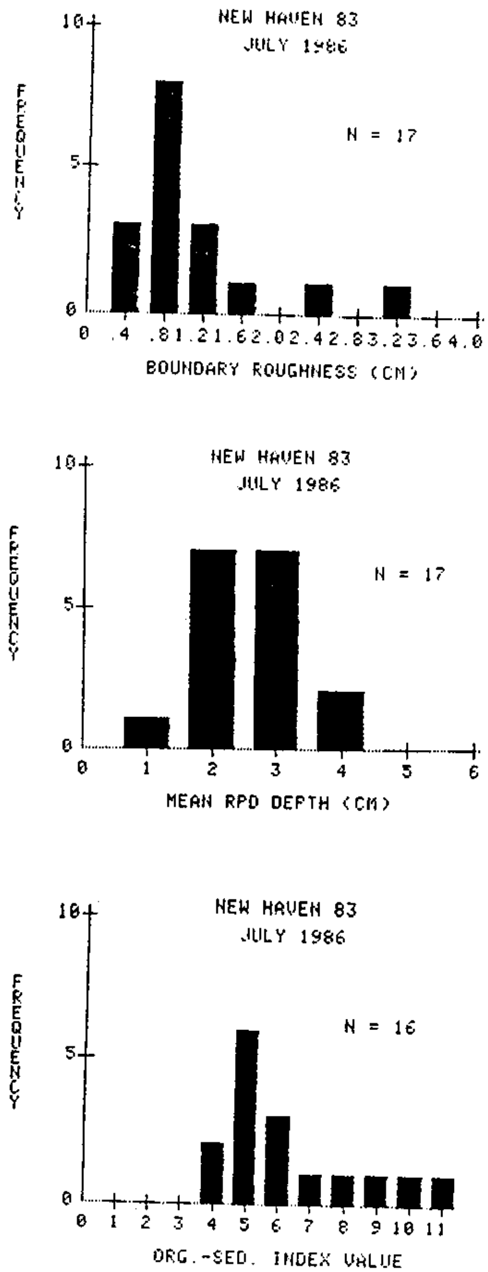


Figure 3-72. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the NH-83 disposal mound, July 1986.

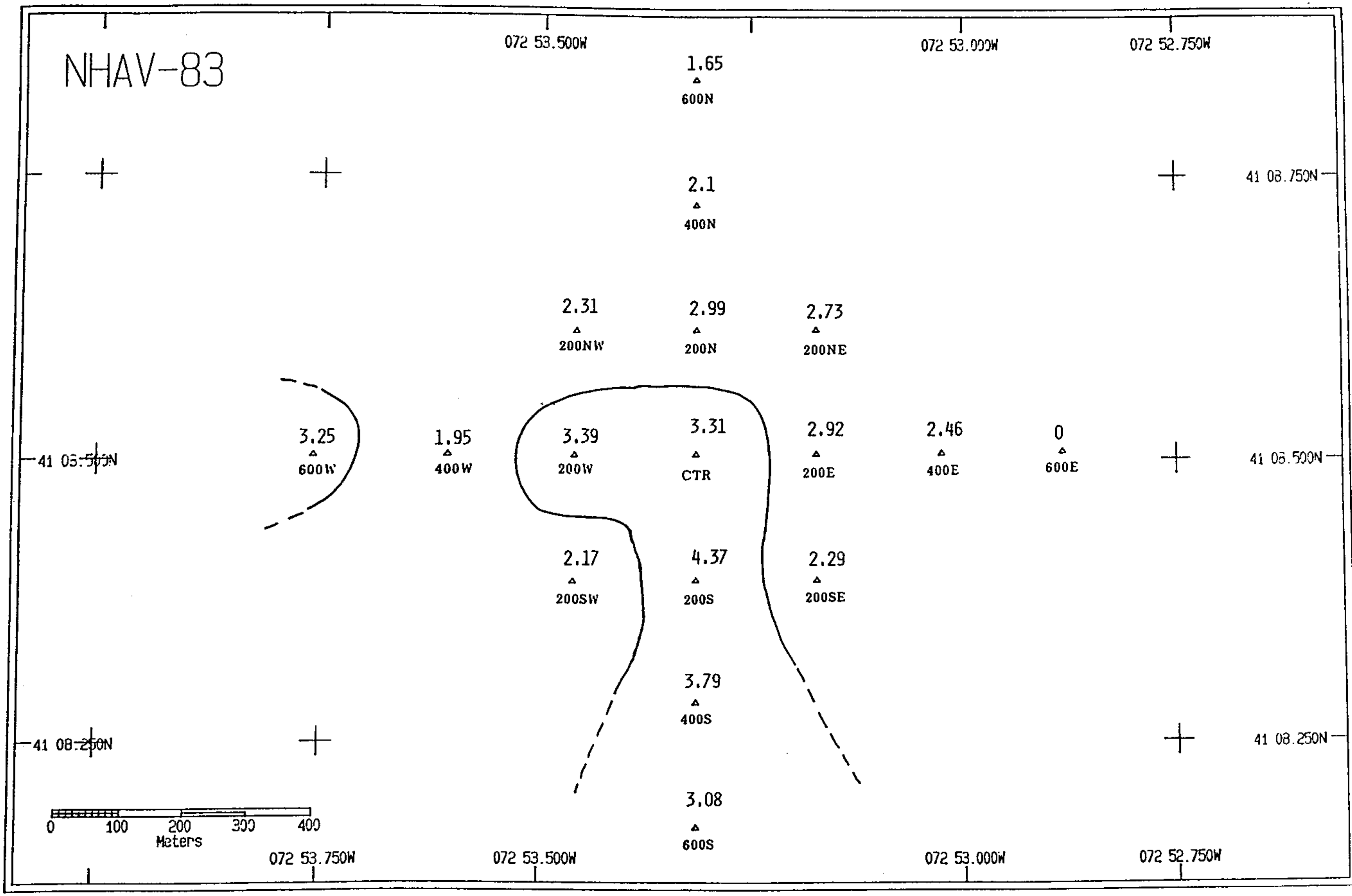


Figure 3-73. The mapped distribution of mean apparent RPD depths at the NH-83 disposal mound, July 1986. Solid lines delimit stations having RPD depths greater than or equal to 3 cm.

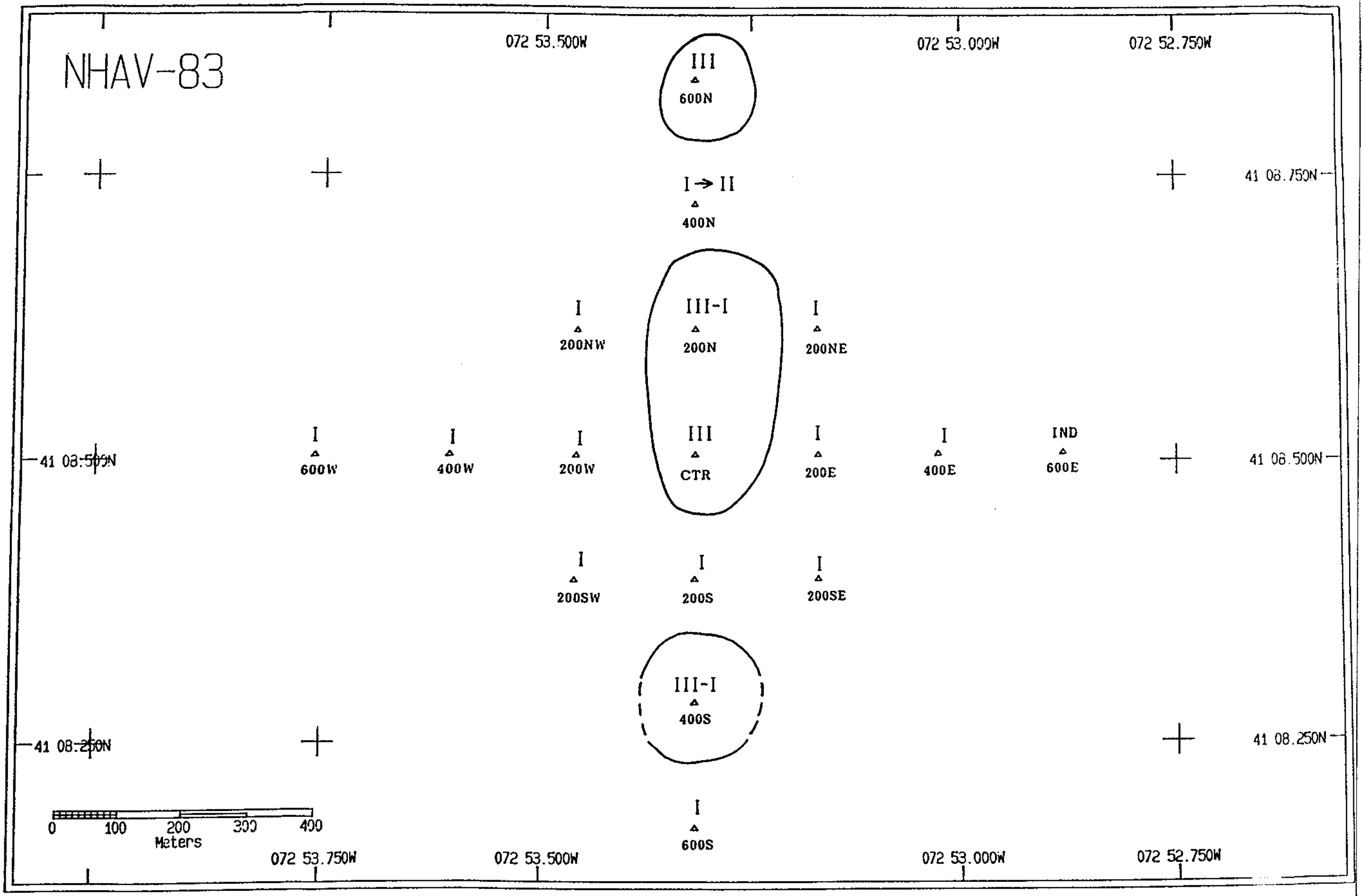


Figure 3-74. The mapped distribution of infaunal successional stages at the NH-83 disposal mound, July 1986. Solid and/or dashed lines delimit stations having Stage III taxa present.

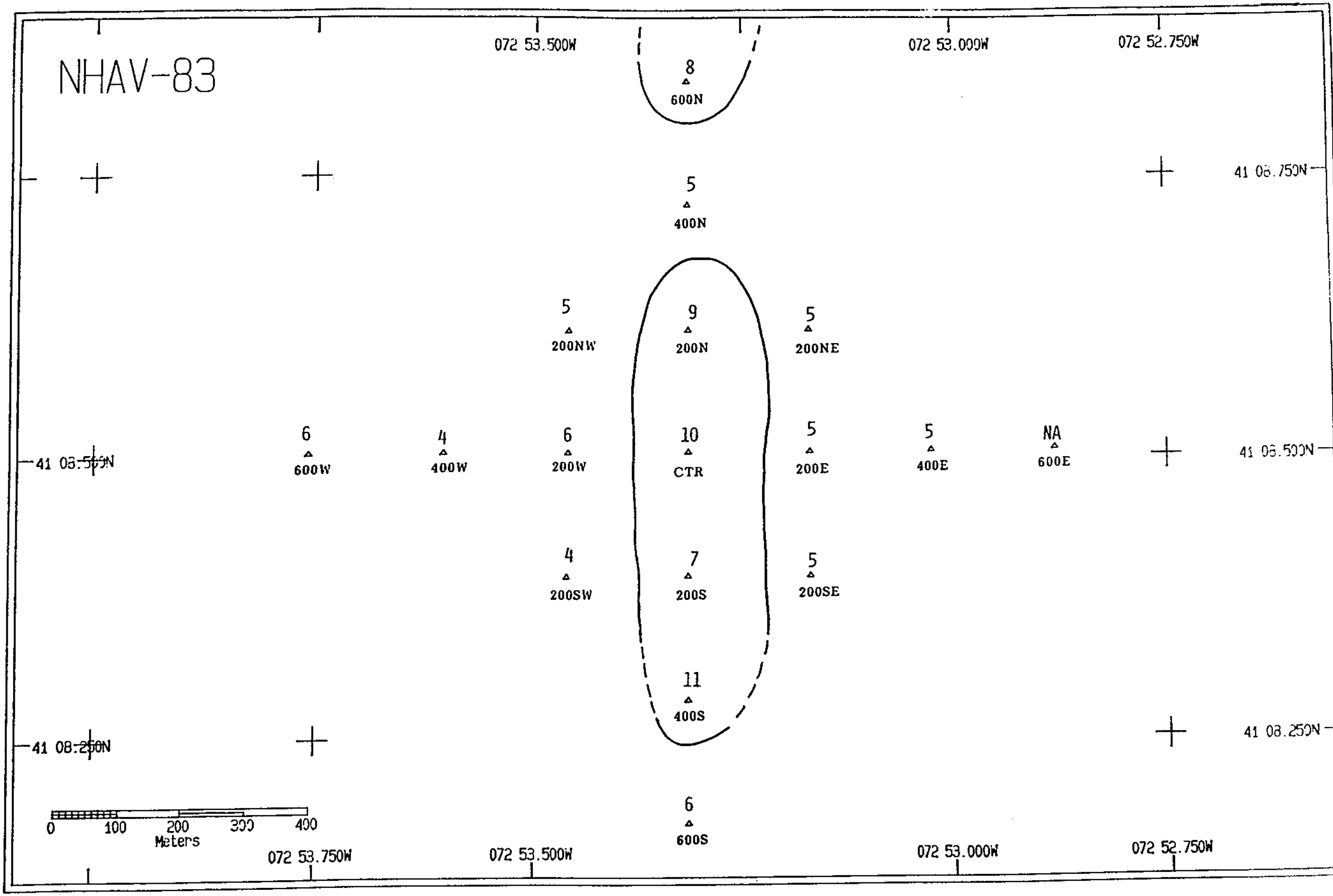


Figure 3-75. The mapped distribution of REMOTS® Organism-Sediment Indices (OSI's) at the NH-83 disposal mound, July 1986. Solid and/or dashed lines enclose stations having OSI values greater than +6.

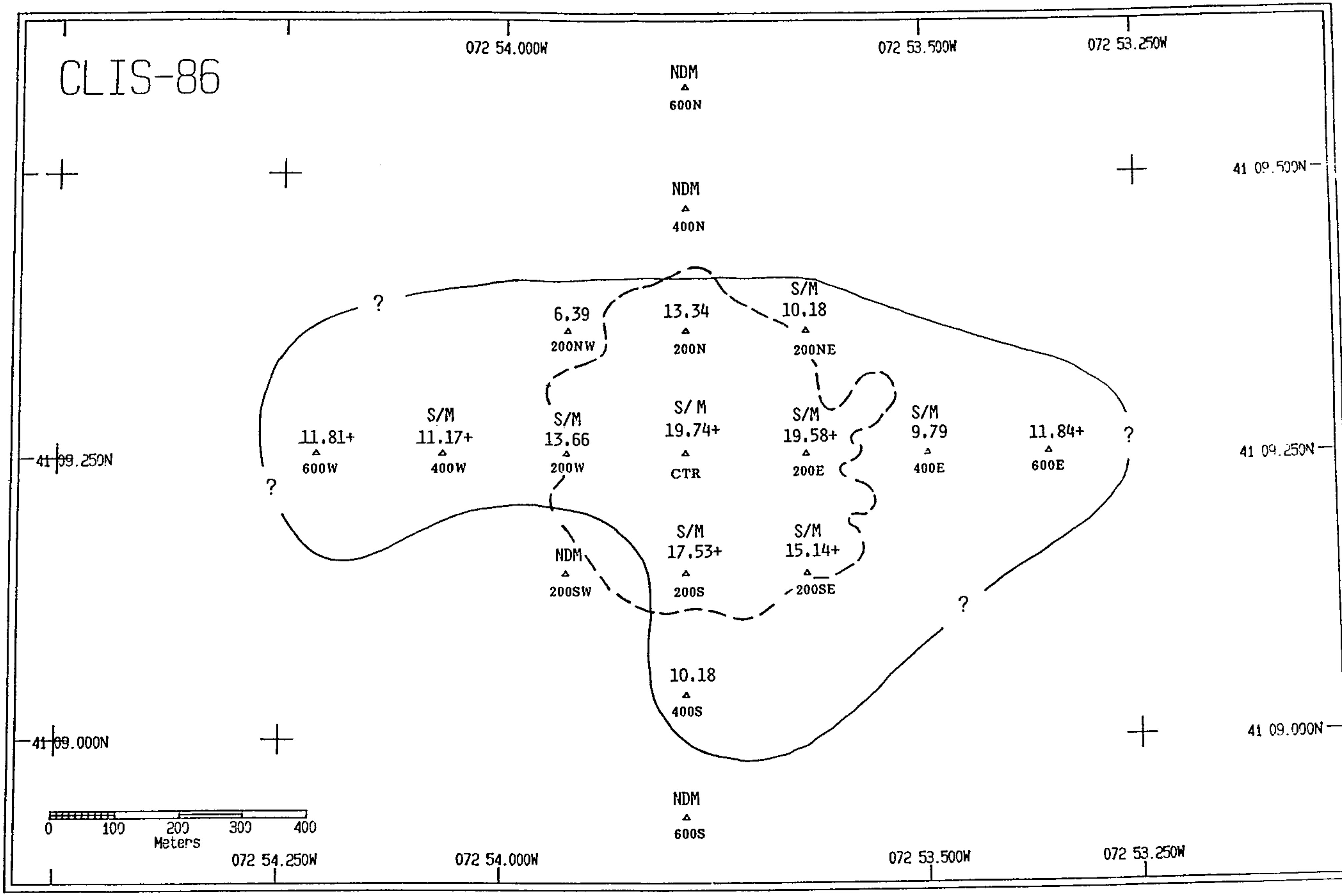
Figure 3-76. Benthic "process" map which indicates the distribution and thickness (cm) of apparent dredged material at the new CLIS-86 disposal mound in July 1986. The solid contour line indicates a "conservative" estimate of the extent of the deposit as determined by REMOTS®. The broken contour line indicates the extent of the mound as determined by precision bathymetry (see Figure 3-4). Symbols are defined as follows:

= Apparent dredged material thickness (cm)

#+ = Apparent dredged material thicker than REMOTS® window penetration

NDM = No apparent dredged material

S/M = Sand over mud stratigraphy



CLIS-86
072 54.000W
072 53.500W
072 53.250W
NDM
600N
NDM
400N
41 09.500N
6.39
200NW
13.34
200N
S/M
10.18
200NE
41 09.250N
11.81+
600W
S/M
11.17+
400W
S/M
13.66
200W
S/ M
19.74+
CTR
S/M
19.58+
200E
S/M
9.79
400E
11.84+
600E
?
NDM
200SW
S/M
17.53+
200S
S/M
15.14+
200SE
10.18
400S
41 09.000N
NDM
600S
0
100
200
300
400
Meters
072 54.250W
072 54.000W
072 53.500W
072 53.250W

Figure 3-76.

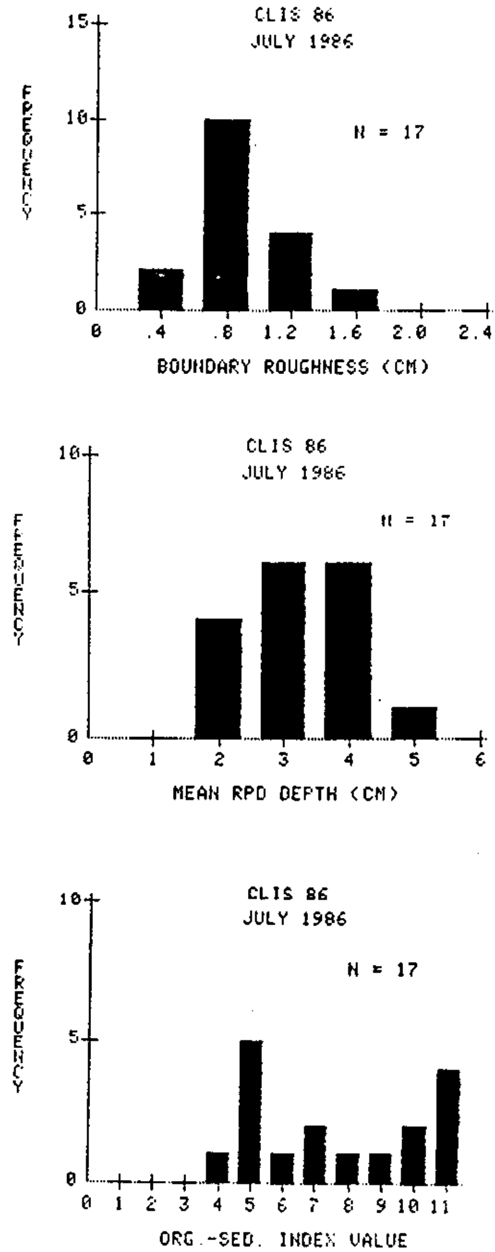


Figure 3-77. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the CLIS-86 disposal mound, July 1986.

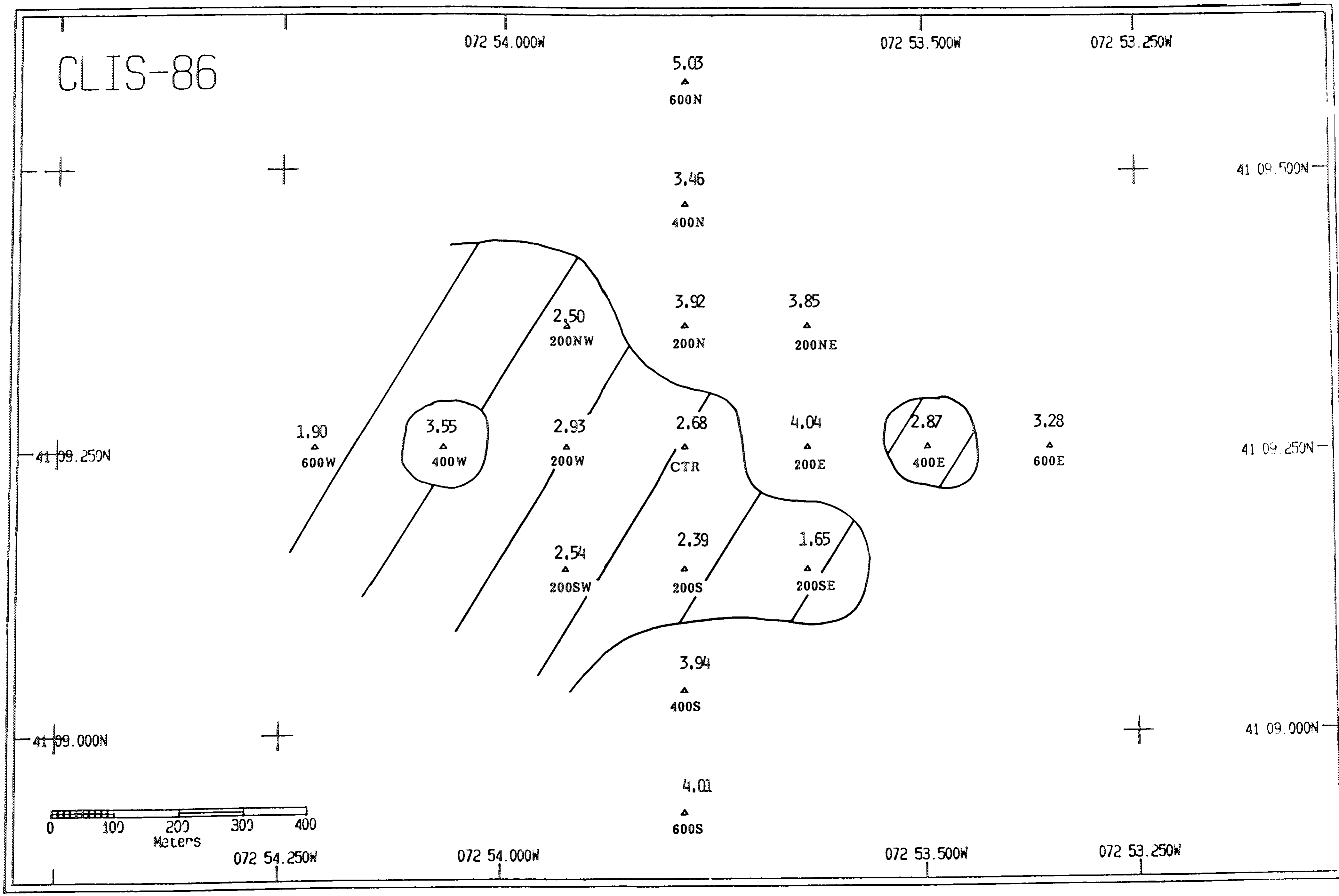


Figure 3-78. The mapped distribution of mean apparent RPD depths (cm) at the CLIS-86 disposal mound, July 1986. Hatched area indicate station having RPD depths less than or equal to 3 cm.

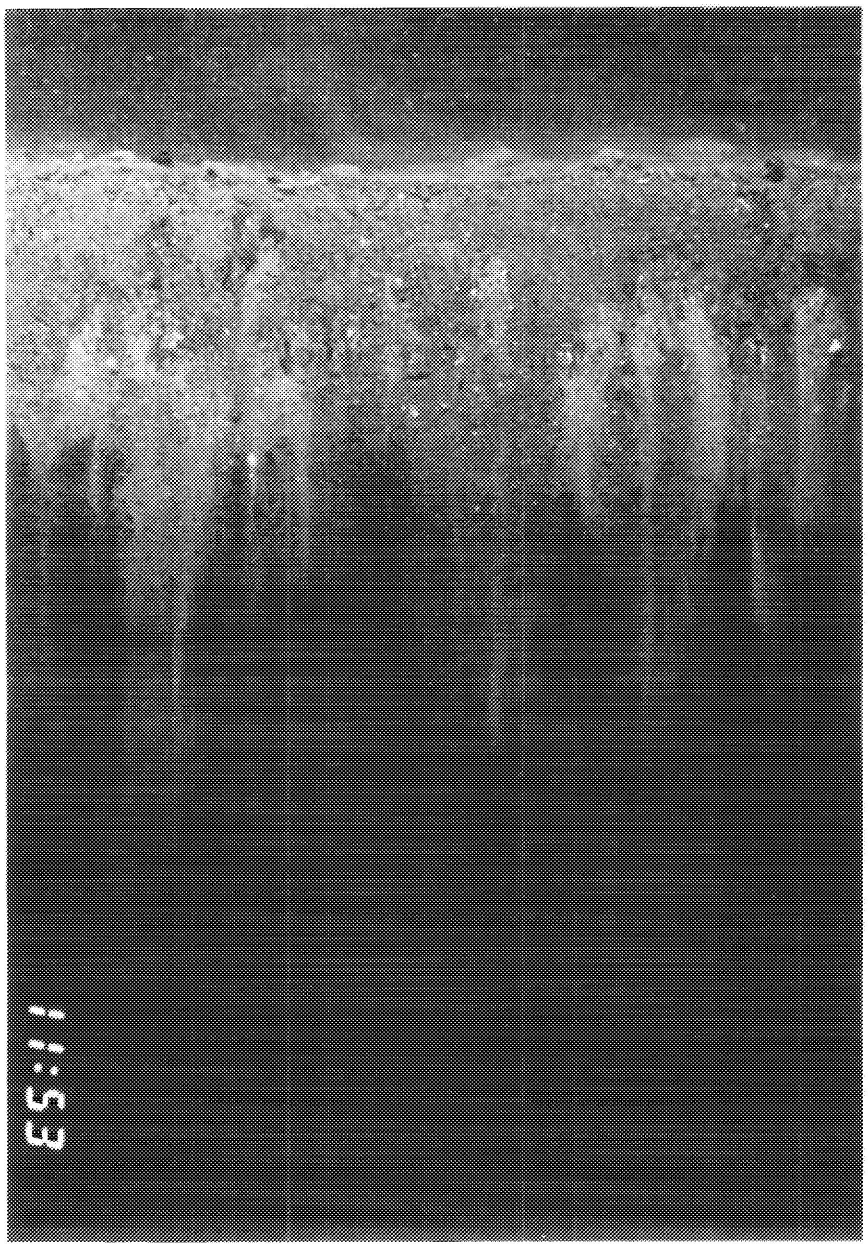


Figure 3-79. REMOTS® image from station 200SE showing a thin layer of low reflectance sediment overlying high reflectance sediment. Scale = 1X.

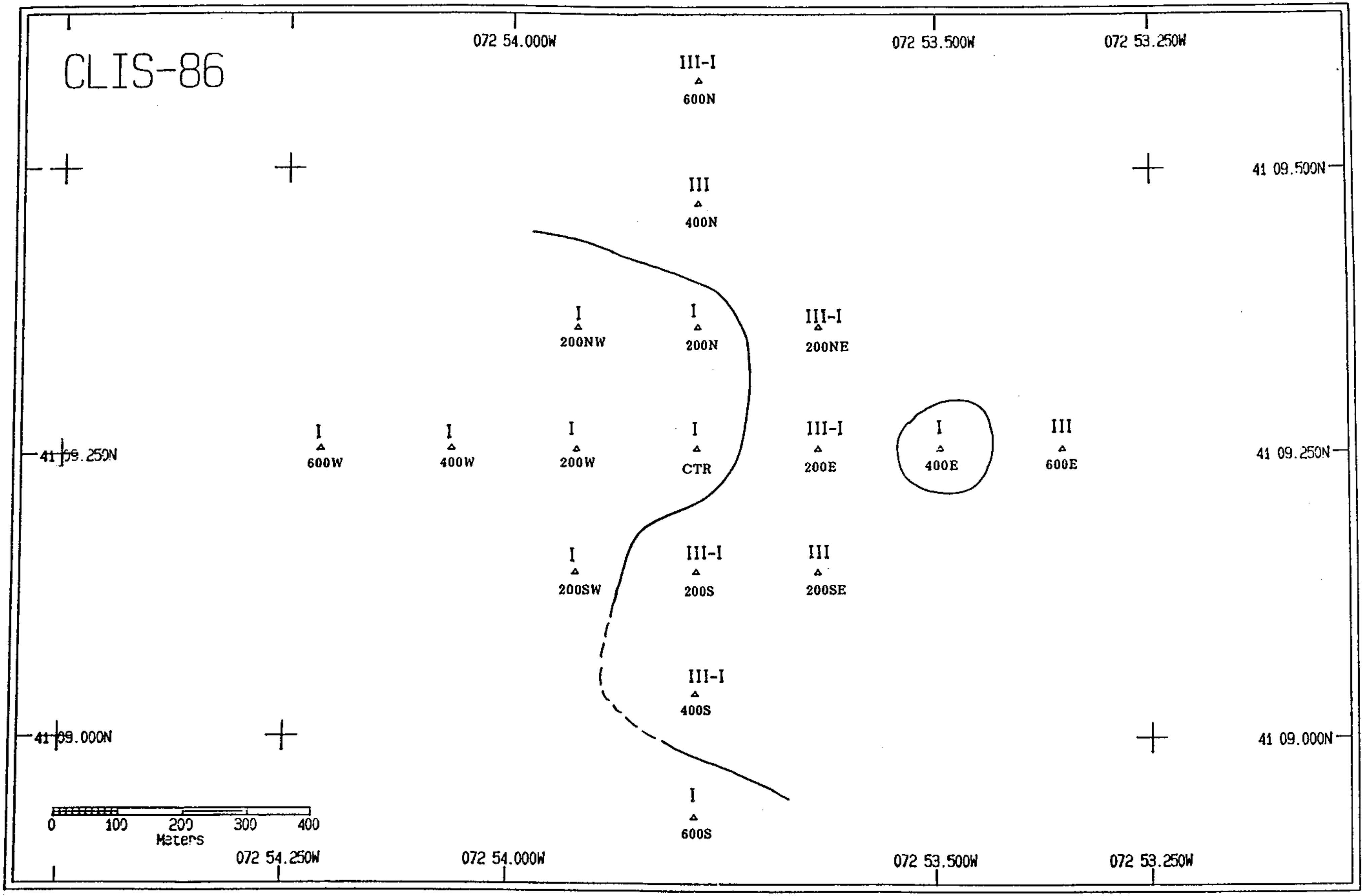


Figure 3-80. The mapped distribution of infaunal successional stages at the CLIS-86 disposal mound, July 1986. Solid and/or dashed lines delimit stations having only Stage I taxa.

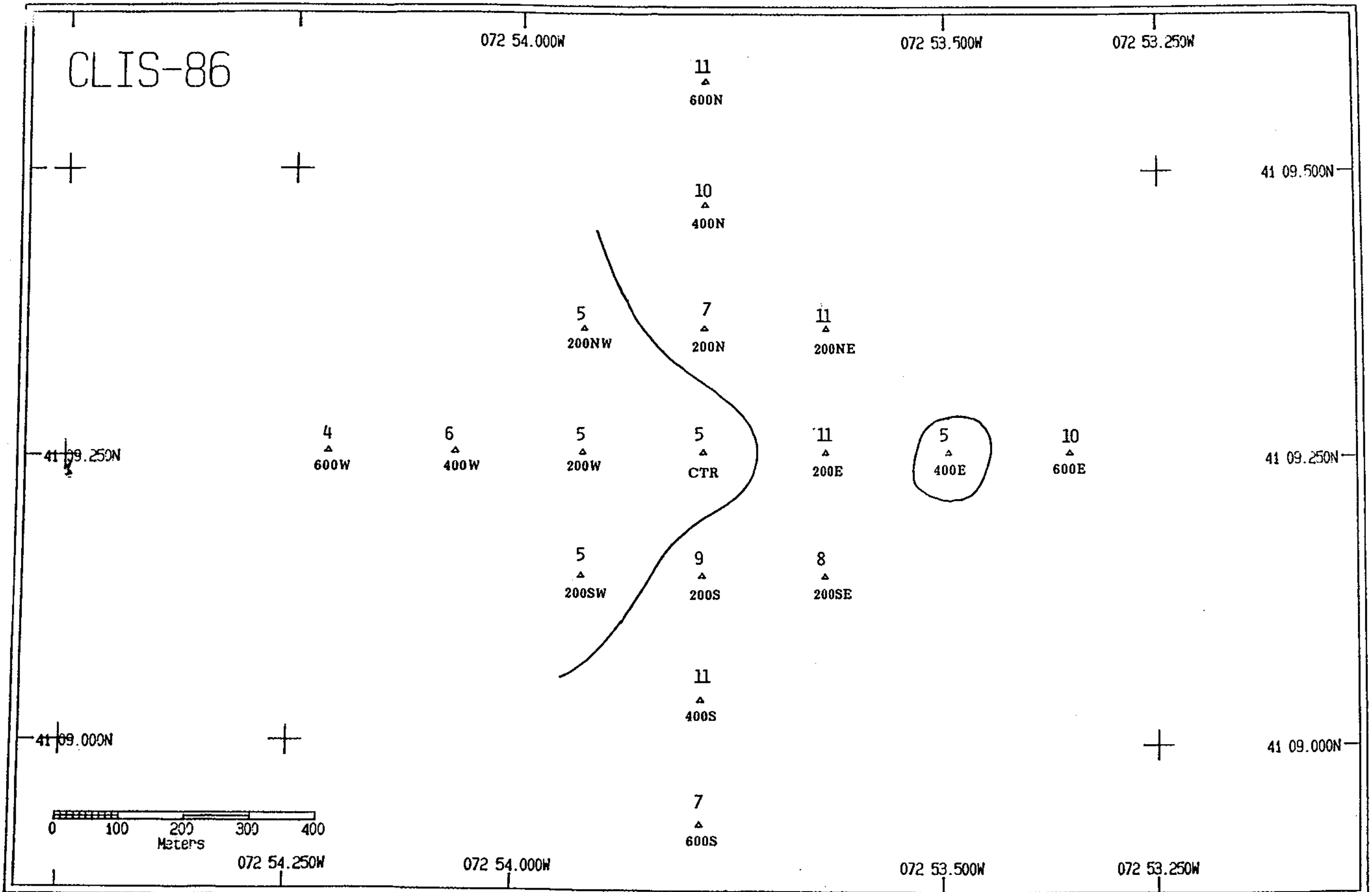


Figure 3-81. The mapped distribution of REMOTS®, Organism-Sediment Indices (OSI's) at the CLIS-86 disposal mound, July 1986. Solid lines delimit stations having OSI values less than +6.

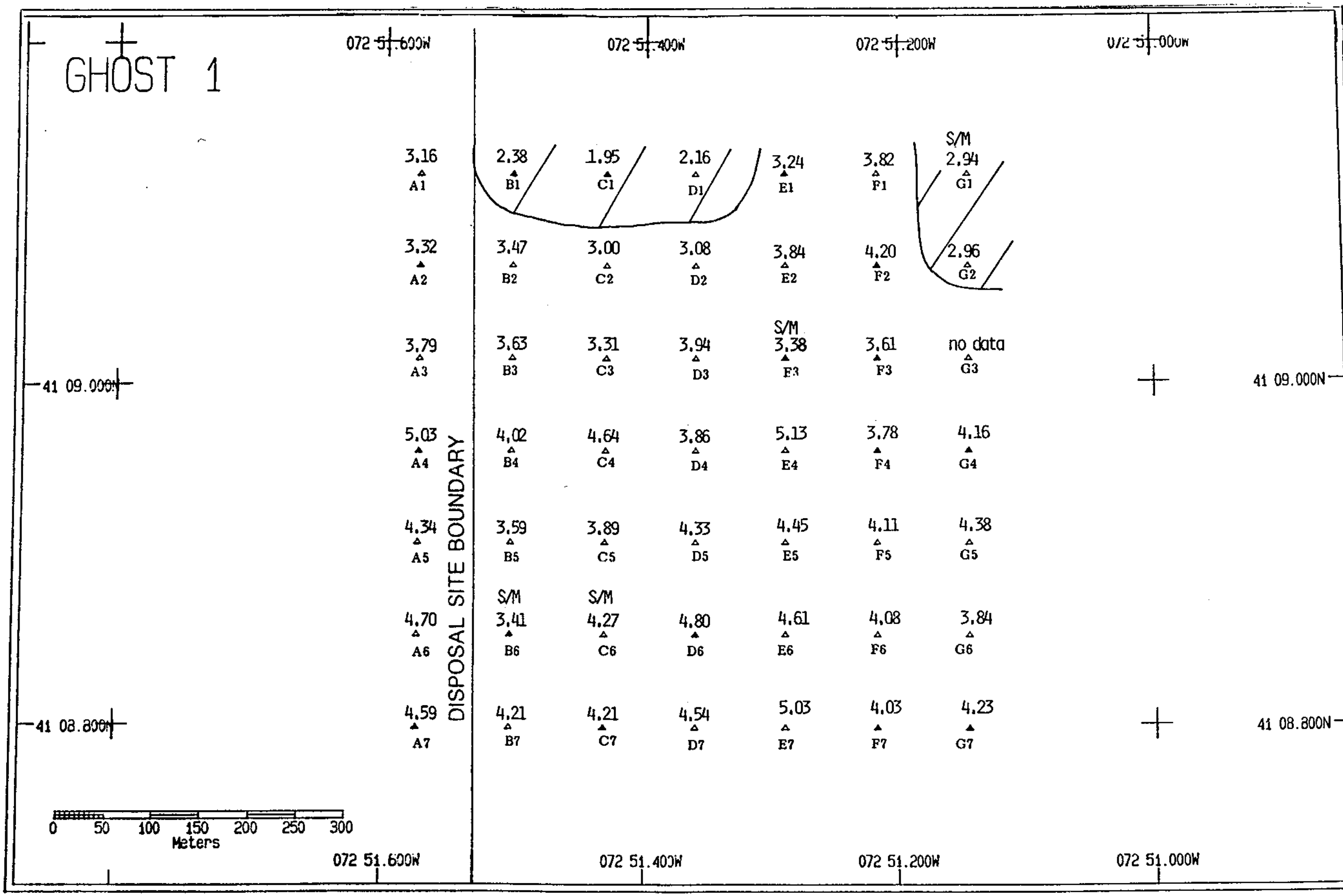


Figure 3-82. The mapped distribution of mean apparent RPD depths (cm) at the GHOST-1 site, July 1986. Hatched areas indicate stations having RPD depths less than or equal to 3 cm. Stations having sand over mud stratigraphy are indicated by the symbol S/M, and stations having small-scale boundary roughness greater than 1.0 cm are indicated by a blackened triangle.

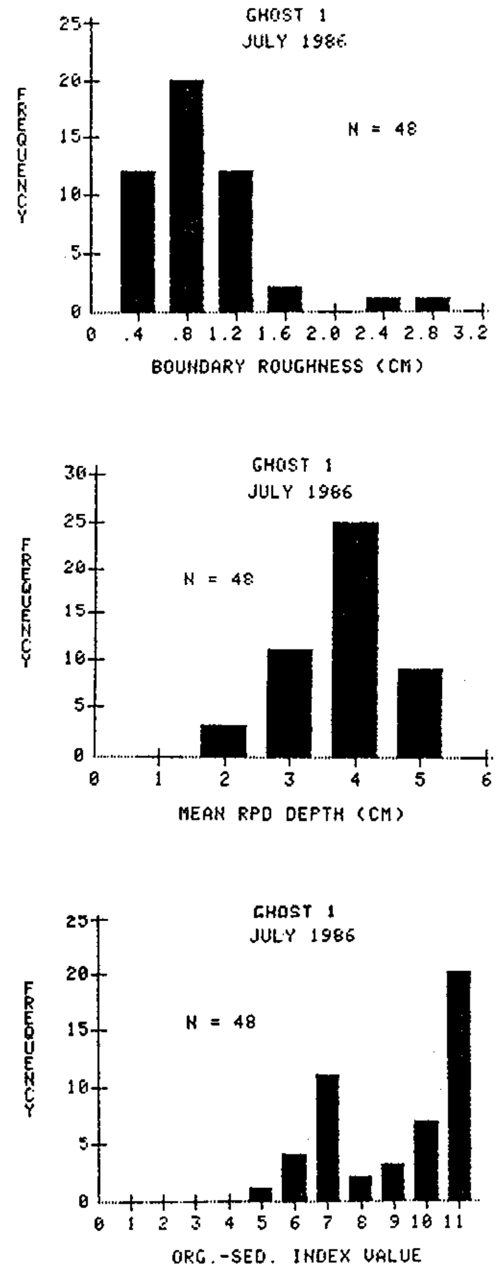


Figure 3-83. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the GHOST-1 site, July 1986.

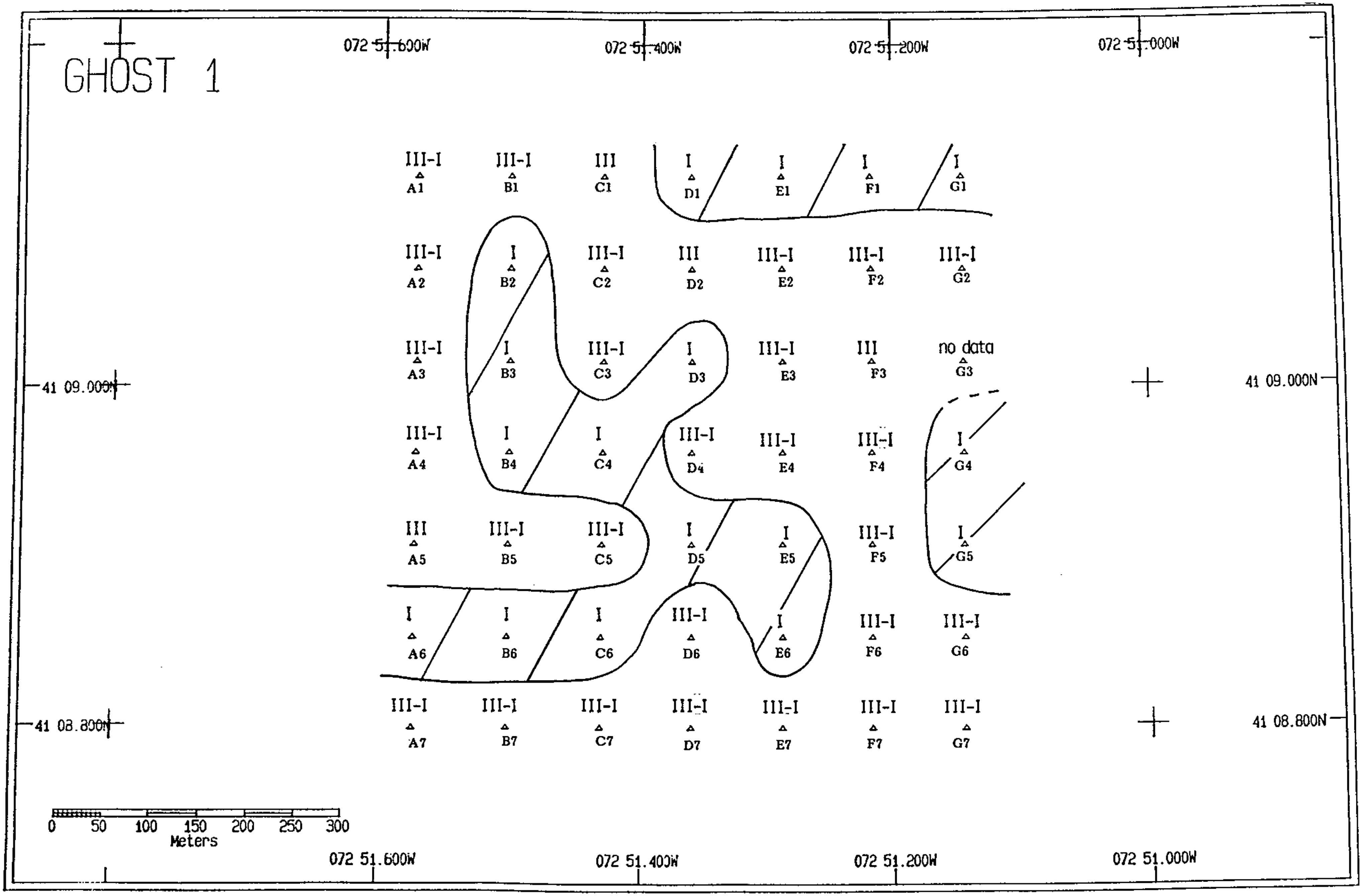


Figure 3-84. The mapped distribution of infaunal successional stages at the GHOST-1 site, July 1986. Hatched areas delimit stations having only Stage I taxa.

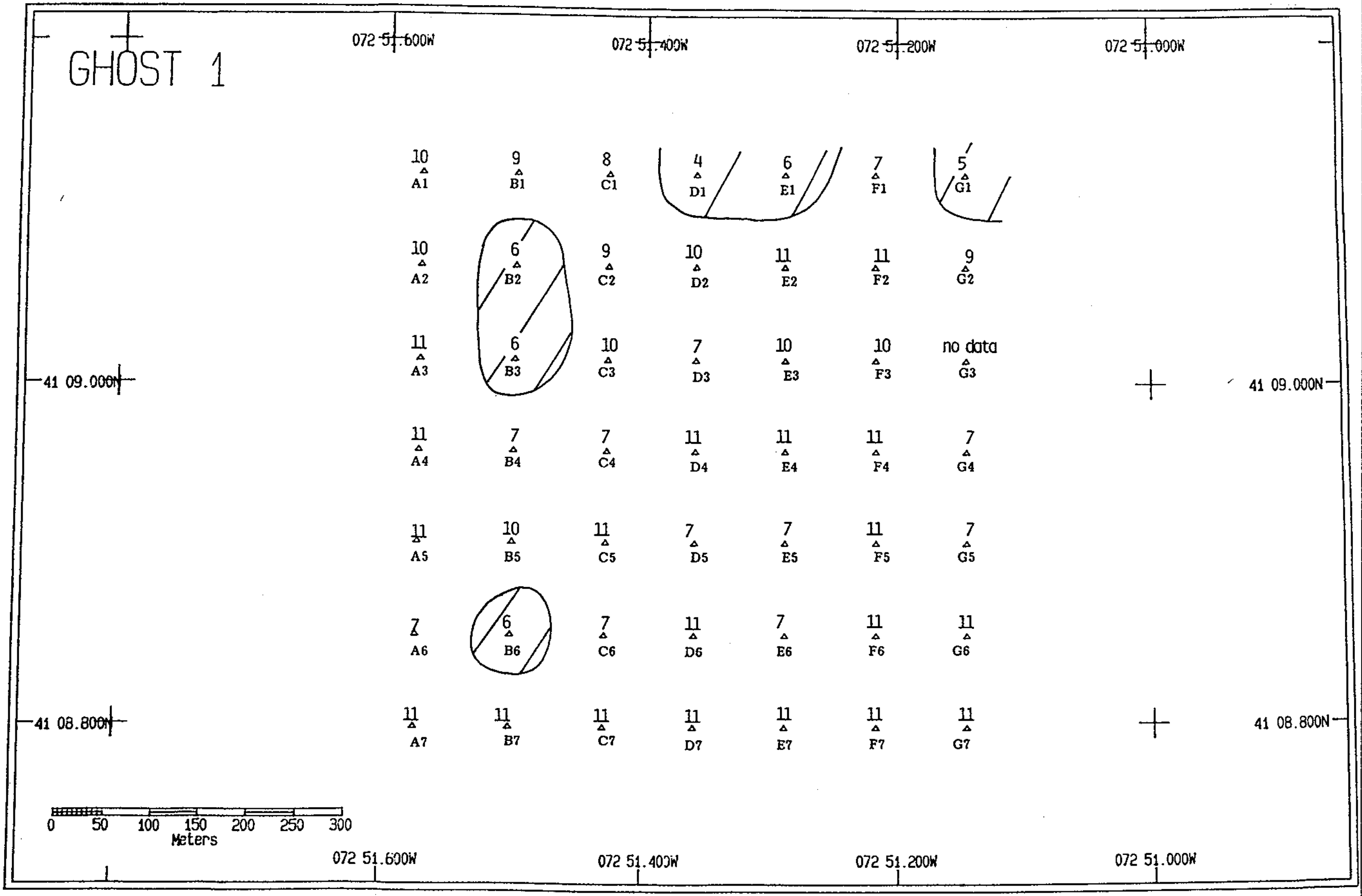


Figure 3-85. The mapped distribution of REMOTS® Organism-Sediment Indices (OSI's) at the GHOST-1 site, July 1986. Hatched areas delimit stations having OSI values less than or equal to +6.

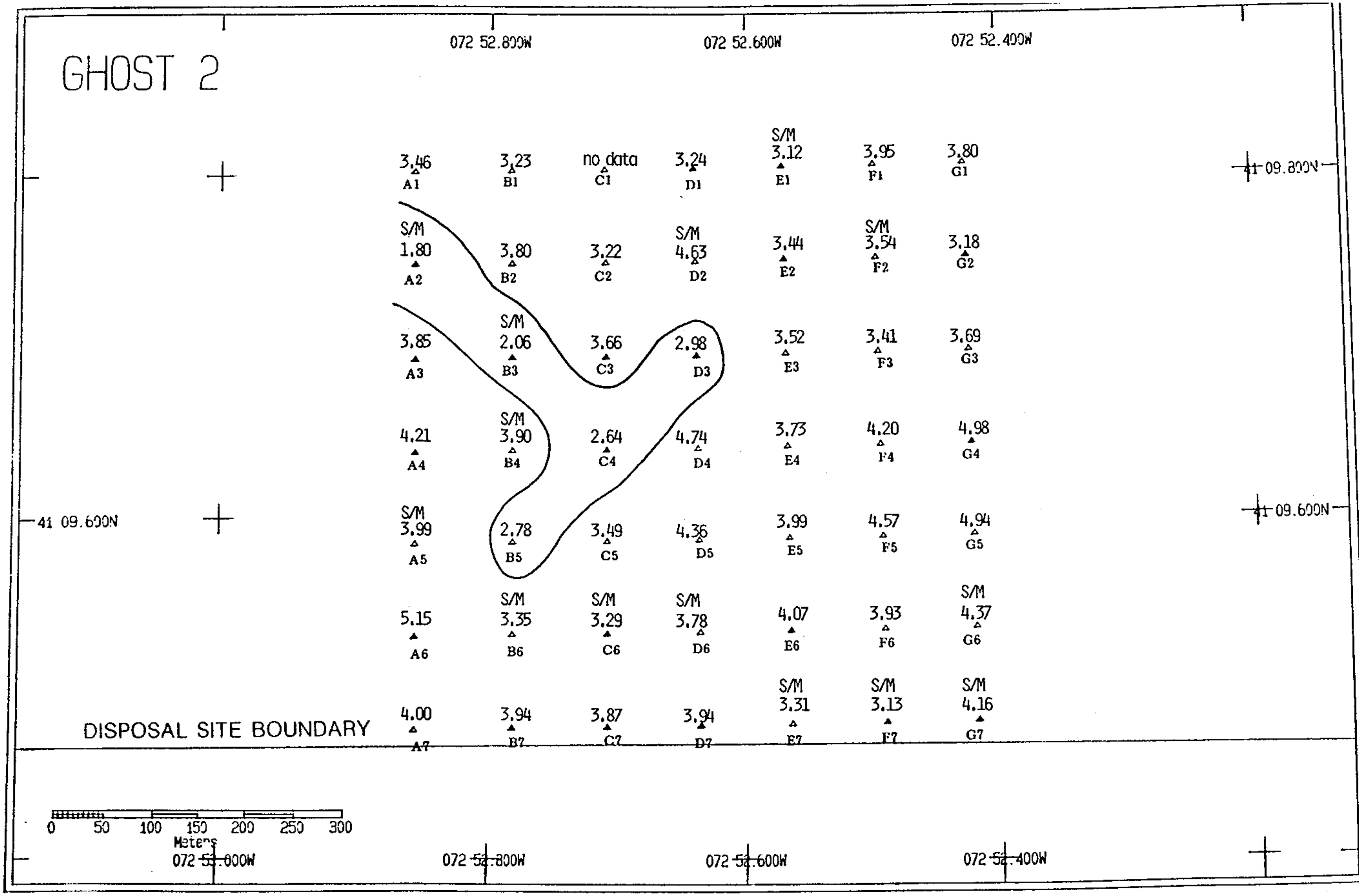


Figure 3-86. The mapped distribution of mean apparent RPD depths (cm) at the GHOST-2 site, July 1986. Solid lines indicate stations having RPD depths less than or equal to 3 cm. Stations having sand over mud stratigraphy are indicated by the symbol S/M, and stations having small-scale boundary roughness greater than 1.0 cm are indicated by a blackened triangle.

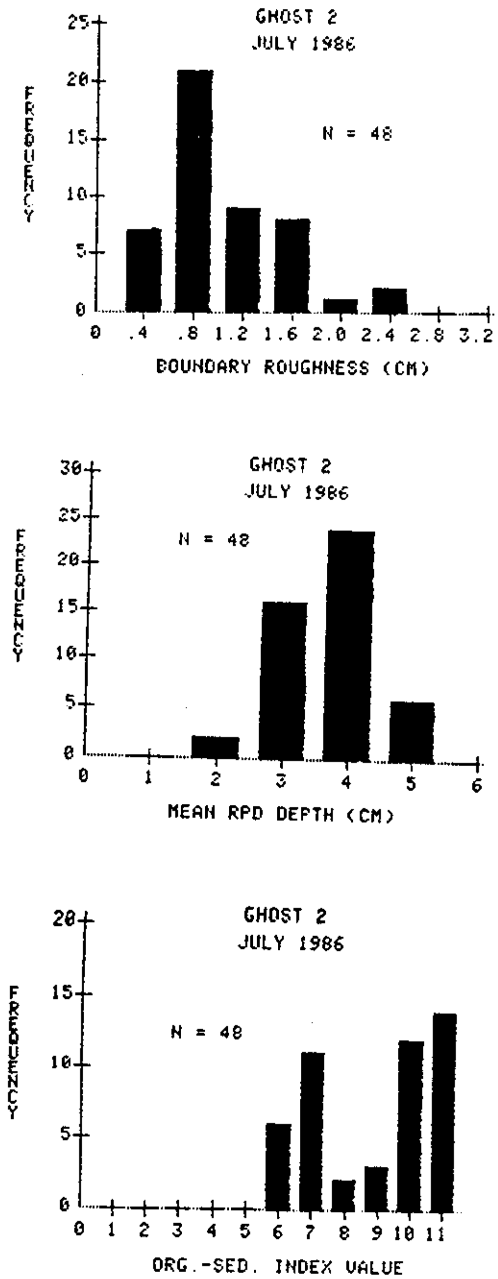


Figure 3-87. Frequency distributions of small-scale boundary roughness, mean apparent RPD depths and OSI values at the GHOST-2 site, July 1986.

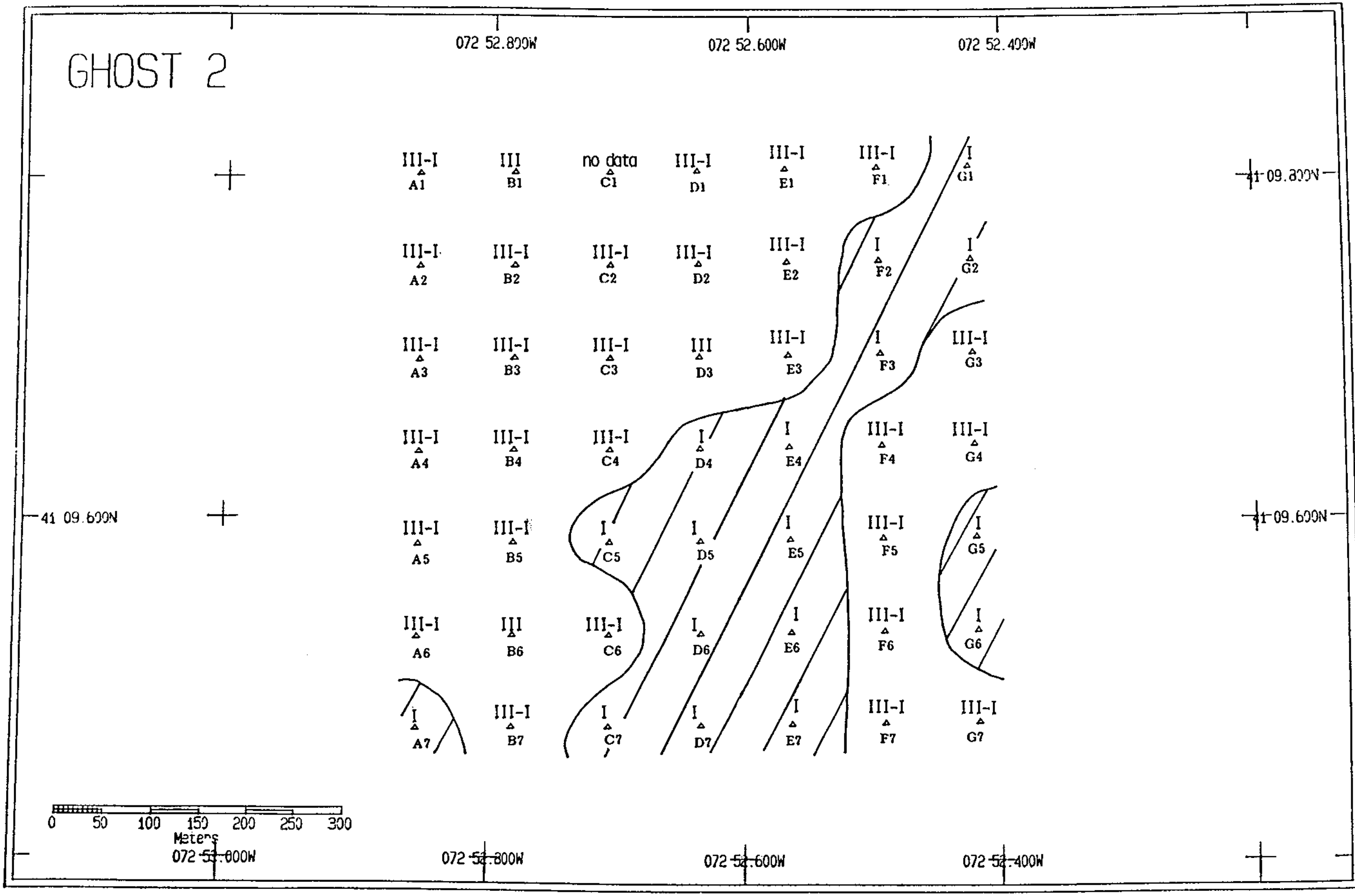


Figure 3-88. The mapped distribution of infaunal successional stages at the Ghost-2 site, July 1986. Hatched areas delimit stations having only Stage I taxa.

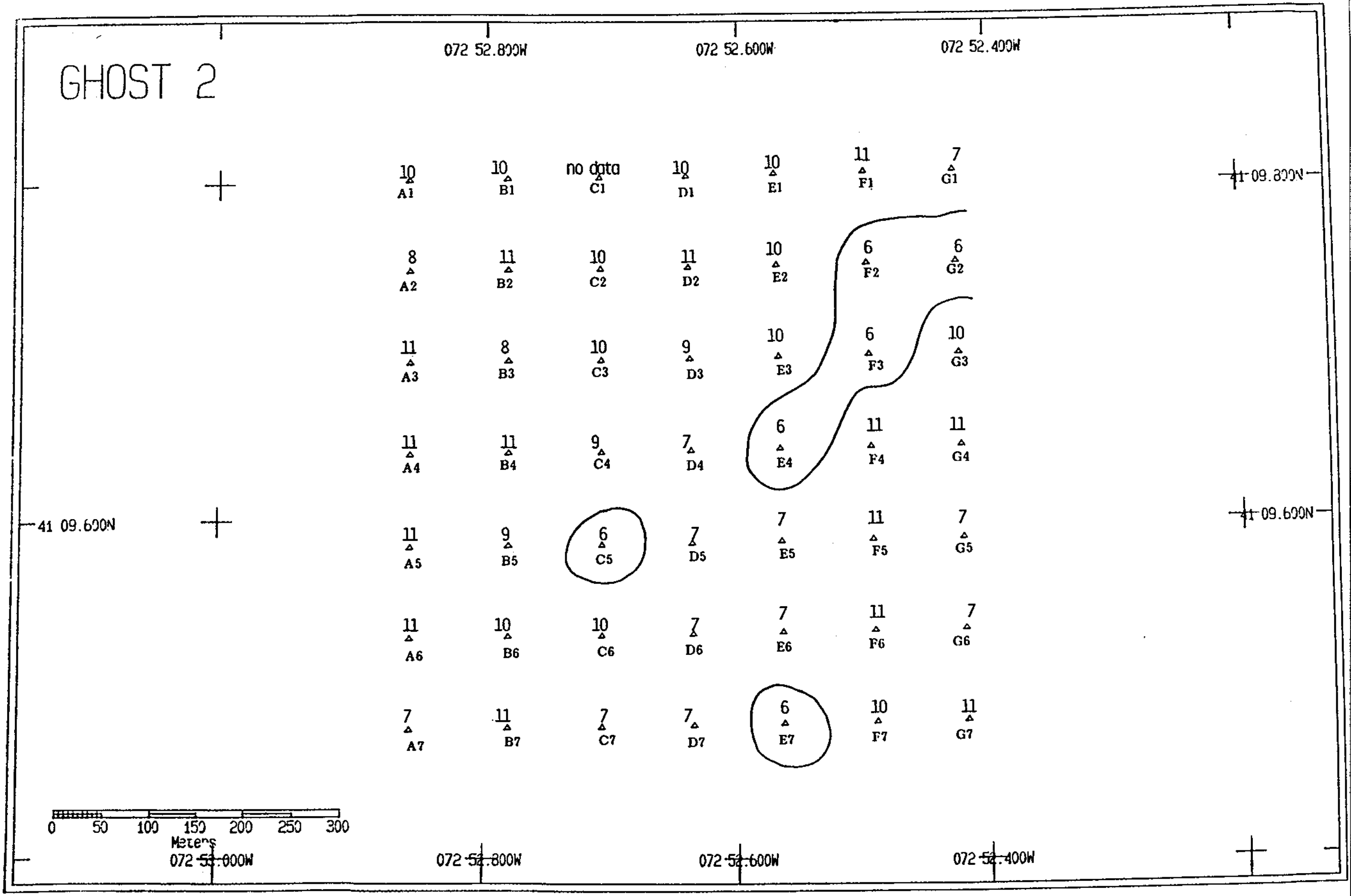


Figure 3-89. The mapped distribution of REMOTS® Organism-Sediment Indices (OSI's) at the GHOST-2 site, July 1986. Solid lines delimit stations having OSI values of +6.

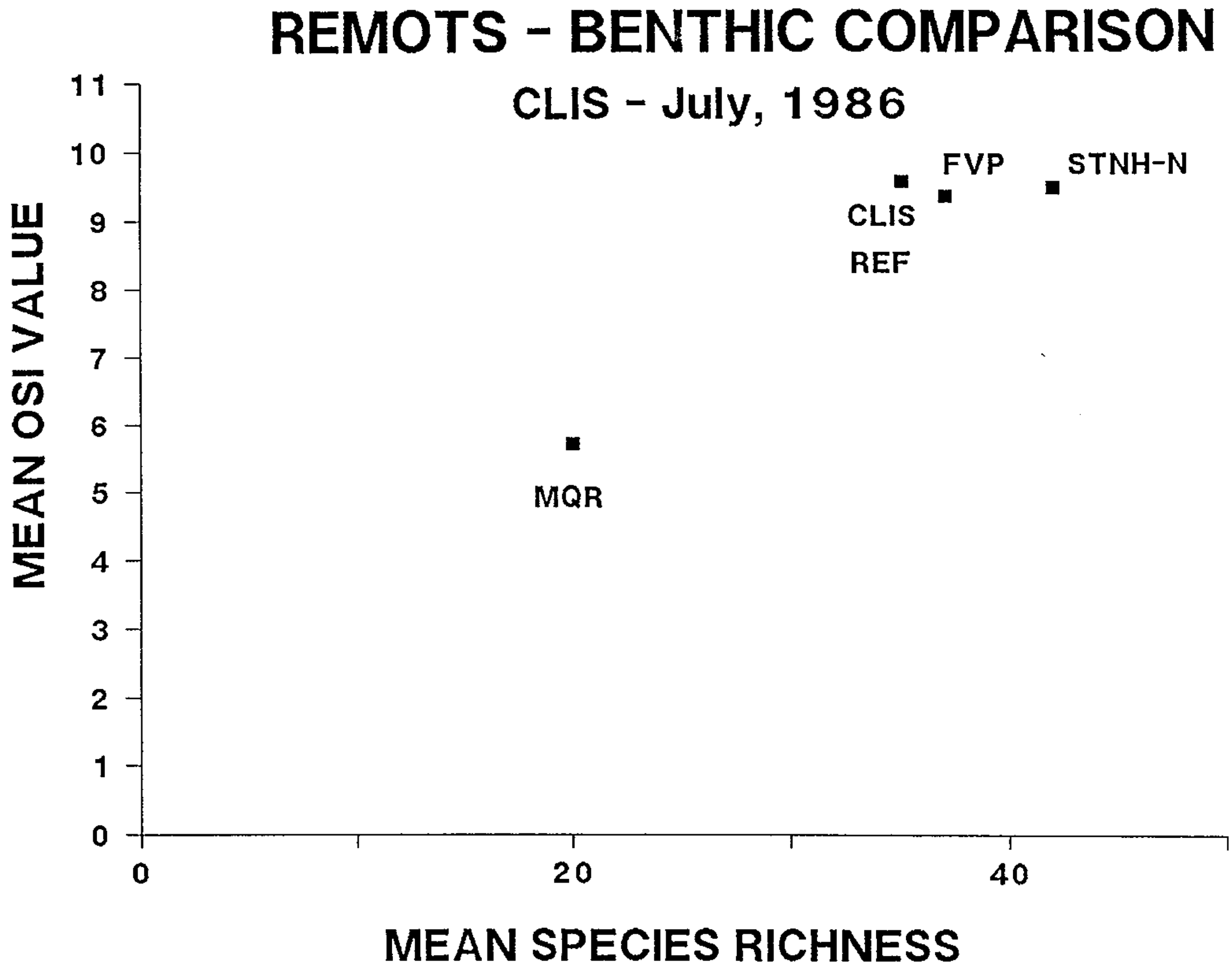


Figure 4-1. Mean species richness value versus mean OSI value for the STNH-N, FVP, and MQR disposal mounds and the CLIS-Reference station.